# Appendix

# Nerves of the Thorax: Atlas of Normal and Pathologic Findings[1]

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An anatomic and imaging atlas was created to provide detailed information about the six pairs of thoracic nerves (phrenic nerves, vagus nerves, recurrent laryngeal nerves, sympathetic trunks, costal nerves, long thoracic nerves). Serial axial computed tomographic (CT) scans of the normal thorax were obtained and included in the atlas, along with drawings showing the proper location of each nerve relative to adjacent anatomic structures. CT scans obtained in both symptomatic and asymptomatic patients with various thoracic diseases were paired with appropriate drawings and normal CT scans in the atlas. This format was designed to help determine the presence and severity of related disease, including injury from surgery, trauma, or penetrating injury, metastatic disease involvement, and, rarely, primary tumor. Although the nerves of the thorax are rarely identified at cross-sectional imaging, their location can be inferred by localizing easily identified anatomic landmarks. Familiarity with the functional anatomy and clinical significance of the nerves of the thorax is important for the correct interpretation of thoracic images.

Index terms: Nerves, 60.92 • Nerves, CT, 60.1211 • Nerves, diseases • Thorax, anatomy, 60.92 • Thorax, CT, 60.1211

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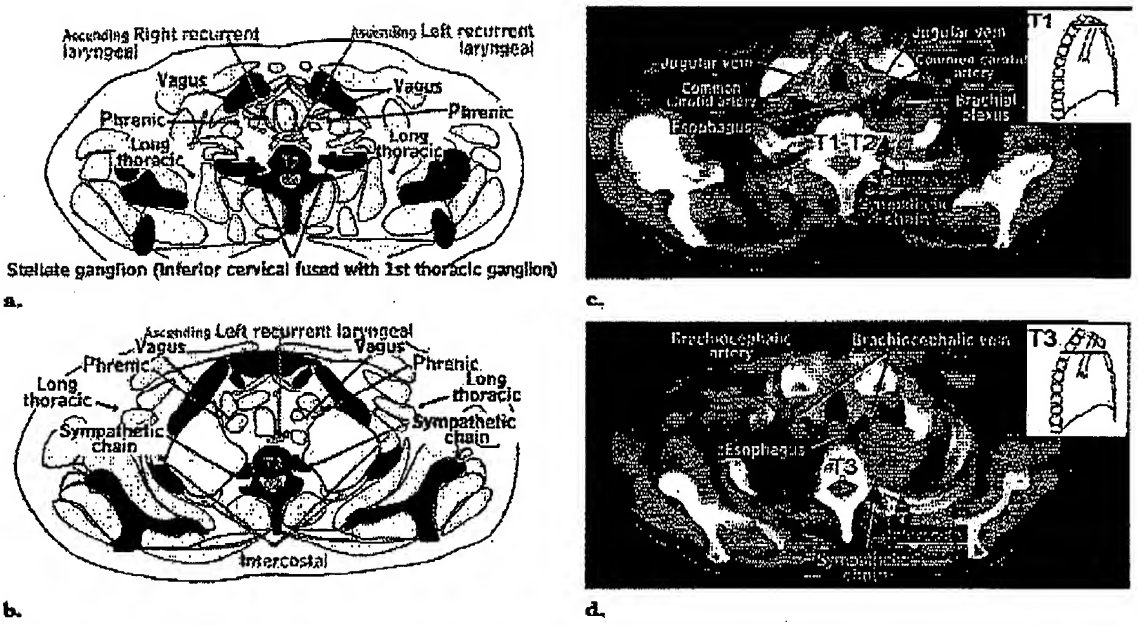


**Figure 1.** (a, b) Drawings (axial view) illustrate the normal thoracic CT anatomy at the level of the T2 (a) and T3 (b) vertebral bodies. (c, d) Pancoast tumor in a 62-year-old man with Horner syndrome. (c) Axial CT scan demonstrates a Pancoast tumor in the left upper lobe (*t*). The mass is contiguous with the first rib in the area of the inferior cervical ganglion (purple arrowhead). The T1 intercostal nerve lies immediately below the first rib. Involvement can cause severe pain in the T1 dermatome of the anteromedial aspect of the arm. (d) Axial CT scan obtained at the level of T3 shows the tumor (*t*) abutting the sympathetic chain. The second intercostal nerve lies above the third rib (gold arrowhead). Damage can cause loss of sensation to the skin of the armpit and the area overlying the second intercostal space.

## Introduction

Anatomic and imaging atlases provide only limited information on the anatomy and function of the intrathoracic nerves, which are often omitted. To help remedy this situation, we obtained serial axial computed tomographic (CT) scans of the normal thorax from the first through the ninth thoracic vertebrae and constructed an anatomic atlas of the thorax. The location of the phrenic nerves, vagus nerves, recurrent laryngeal nerves, sympathetic trunks, costal nerves, and long thoracic nerves was confirmed by one author (G.R.D.) after dissecting 40 cadavers. We color-coded each nerve and placed it in its proper location (relative to adjacent anatomic structures identified at CT) on drawings based on CT scans. To demonstrate the usefulness of these data, we paired CT scans of various thoracic diseases in both symptomatic and asymptomatic patients with appropriate drawings and normal CT scans from the atlas.

In this article, we discuss and illustrate the functional and clinical relevance of each of the six sets of thoracic nerves (1–5). The anatomic and imaging atlas that was created from this information can be used as a reference tool to help determine the presence and severity of related disease.

## Phrenic Nerves

The phrenic nerves lie along the lateral mediastinum and run from the thoracic inlet to the diaphragm (Figs 1a, 1b, 2–4). They course through the upper chest, medial to the mediastinal pleura and the apex of the right or left lung. The right phrenic nerve lies lateral to the right brachiocephalic vein and the superior vena cava. The left phrenic nerve courses along the lateral aspect of the transverse arch of the aorta. The two nerves subsequently pass anterior to their respective pulmonary hila and then inferiorly in a broad vertical plane along the margin of the heart between the

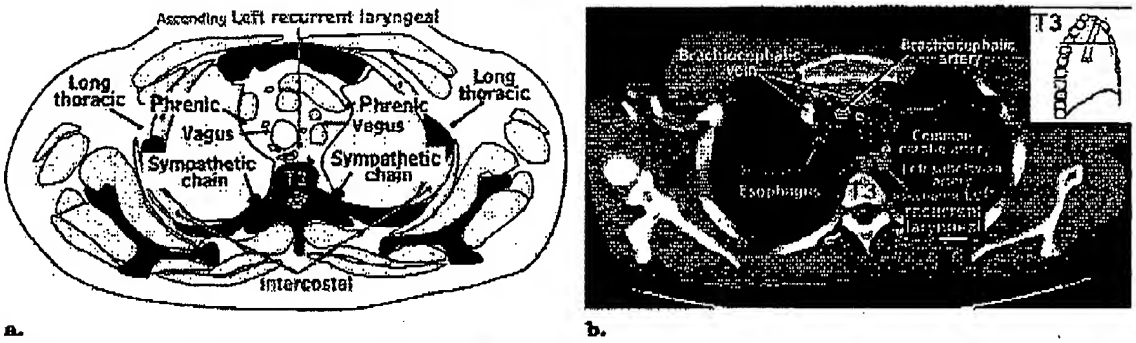


**Figure 2.** (a) Drawing (axial view) illustrates the normal thoracic CT anatomy at the level of T3. (b) Neurofibromatosis in an asymptomatic 28-year-old man. Axial CT scan obtained at the level of T3 shows tumor masses in the region of the phrenic and vagus nerves. Neurofibroma is also present in the region of the ascending left recurrent laryngeal nerve.

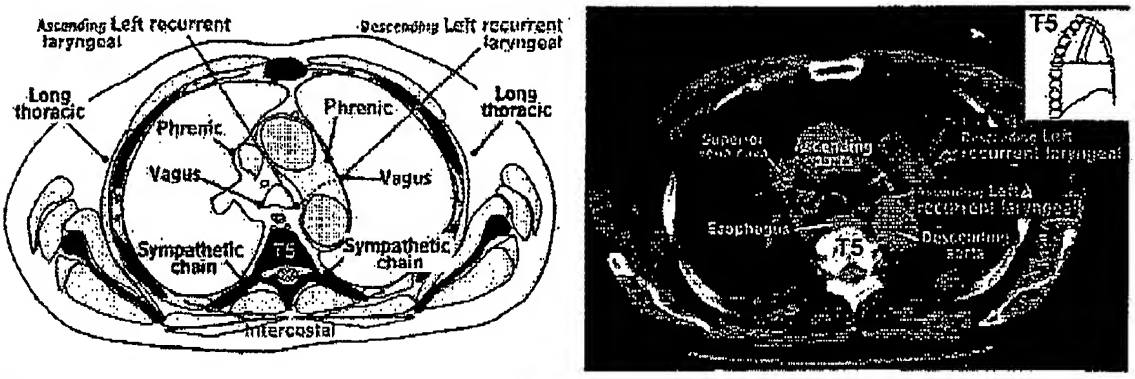


**Figure 3.** (a) Drawing (axial view) illustrates the normal thoracic CT anatomy at the level of T5. (b) Enlarged lymph nodes in a 72-year-old man who presented with hoarseness and a left upper lobe mass. Axial CT scan obtained at the level of T5 shows enlarged lymph nodes in the left mediastinum at the aortopulmonary window and left paratracheal regions, which lie along the course of the ascending and descending left recurrent laryngeal nerve. Lesions in this region explain the patient's hoarseness. The adjacent vagus and phrenic nerves were not clinically affected in this case.

fibrous pericardium and the mediastinal pleura (5). The phrenic nerves can occasionally be visualized at cross-sectional imaging (6,7).

The phrenic nerves provide motor innervation to the diaphragm and sensory innervation to the central intrathoracic and peritoneal surfaces of the diaphragm. They also innervate the pericardium and mediastinal pleura and mediate pain from these areas to the neck and shoulder. Manifestations of phrenic nerve disease include diaphragmatic paralysis with elevation or persistent hiccups (8).

Primary tumors of the phrenic nerves are rare but are seen in neurofibromatosis (9). Metastatic disease involvement from primary lung cancer is more common (10). Injury to the phrenic nerves can occur from penetrating injury, surgery, and trauma from suboptimal placement of right-sided subclavian catheters or cardiac leads (11–13). Temporary palsy and diaphragmatic elevation that resolves over time can occur after open-heart surgery (14). The phrenic nerves can be compromised by enlarged lymph nodes, bronchial obstruction, pericardial disease, cardiomegaly, myocardial infarction, and subphrenic disease (8).

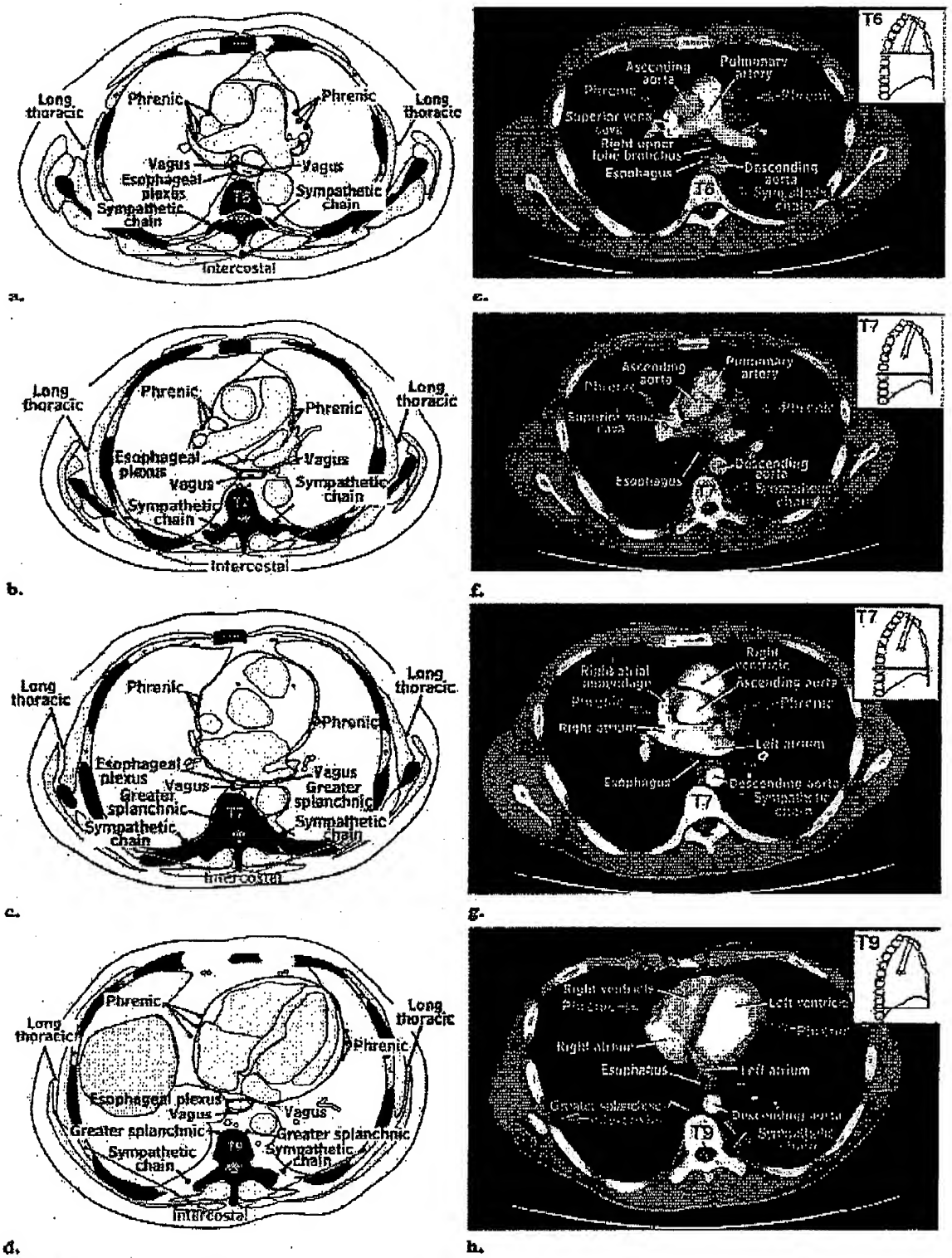


Figure 4. (a–d) Drawings (axial view) illustrate the normal thoracic CT anatomy between the levels of T6 and T9. (e–h) Neurofibromatosis in an asymptomatic 28-year-old man. Serial axial CT scans obtained at the same four levels demonstrate neurofibromas involving the phrenic and vagus nerves bilaterally, the sympathetic chain, and a right intercostal nerve.

## Vagus Nerves, Esophageal Plexus, and Vagal Trunks

The complex anatomy of the vagal fibers is further complicated by the fact that their names change as they descend through the thorax. In brief, the right and left vagus nerves enter the thorax between their respective brachiocephalic veins and the subclavian artery, medial to the mediastinal pleura. They descend posterior to their respective pulmonary hila, ramify to form the esophageal plexus, and then pass through the esophageal hiatus of the diaphragm as the anterior and posterior vagal trunks.

There are, however, small but significant differences between the pathways of the right and left vagal fibers. The right vagus nerve descends in the mediastinum between the lung and the trachea before dividing into several branches to the esophagus, which form part of the esophageal plexus. Most of these plexal fibers reunite behind the esophagus to form the posterior vagal trunk, which continues through the diaphragm to the posterior aspect of the stomach. The left vagus nerve descends in the mediastinum between the left common carotid artery and left subclavian artery. It continues immediately lateral to the transverse arch of the aorta. Inferiorly, it runs lateral to the trachea and esophagus. It ramifies to join the esophageal plexus, which reunites in front of the esophagus to form the anterior vagal trunk, and continues through the diaphragm to the anterior aspect of the stomach (5).

The vagus nerves and their plexuses mediate esophageal swallowing, gastric emptying, and meal satiety. Stimulation leads to increased peristalsis and increased activity of the secretory glands of the gastrointestinal tract from the esophagus to the middle of the transverse colon (15). Stimulation of the cardiac branches of the vagus nerves will lead to a decrease in heart rate (16). Manifestations of vagus nerve impairment include gastroesophageal reflux, achalasia, and dysmotility disorders (17).

As with all the thoracic nerves, primary tumors are rare. The most commonly reported neoplasms are paragangliomas and neurofibromas (18–22). Metastatic involvement may occur rarely. Injury to the vagus nerves can occur from penetrating injury, thyroid or parathyroid surgery, and trauma (23).

## Recurrent Laryngeal Nerves

The recurrent laryngeal nerves follow an asymmetric pathway through the upper chest (Figs 1a, 1b, 2, 3). The right recurrent laryngeal nerve originates from the right vagus nerve at the level of the right subclavian artery and loops under this artery to ascend out of the thorax (Fig 1a). The left recurrent laryngeal nerve originates from the left vagus nerve at the level of the transverse aortic arch and loops under it immediately posterior to the ligamentum arteriosum to ascend along the posterolateral tracheal margin and exit the thorax (Figs 1a, 1b, 2, 3) (5). The recurrent laryngeal nerves provide ipsilateral motor innervation to the intrinsic laryngeal muscles for vocalization and sensory innervation to the upper esophagus. They also mediate airway sensation from the level of the true vocal cords to the carina (24). Damage or tumoral involvement is nearly always unilateral and manifests as hoarseness, brassy cough, or vocal cord weakness (8).

Primary tumors are rare, but the left recurrent laryngeal nerve is often involved when metastatic lung cancer involves the left side of the mediastinum, either by direct invasion or lymph node spread (25). Other mediastinal tumors that can involve the recurrent laryngeal nerve include esophageal, tracheal, and thyroid tumors (26–28). Lymphadenopathy from inflammatory and infectious causes may also affect this nerve (29). Mass effect from enlarged mediastinal structures (eg, vascular aneurysms), an enlarged left atrium, right nerve palsy of the cervical aortic arch, tracheal diverticulum, and lung collapse have also been reported (8,30–34).

## Sympathetic Chains and Splanchnic Branches

The sympathetic chains are paired, symmetric structures that extend from the thoracic inlet to the diaphragm (Figs 1b–d, 2a, 3a, 4). These fibers and ganglia run in a vertical line that crosses the necks of the ribs. They are covered by the parietal pleura, except for the most inferior segment of the right chain. Three splanchnic branches emerge from each chain and pass medially to the abdominal sympathetic ganglia (5).

The upper part of this system mediates dilation of the pupil, the levator muscles of the upper eyelids, the sweat glands, vasoconstriction of superficial vessels of the skin, and vasodilation of the deep arteries to striated muscles (8). In the gastrointestinal tract, the sympathetic system causes a decrease in bowel peristalsis and inhibits secretory gland activity from the esophagus to the middle of the transverse colon. Stimulation of the

branches to the heart and lungs leads to increases in heart and respiratory rates.

One of the most common diseases to involve the thoracic sympathetic system is Pancoast tumor (Fig 1c, 1d) (35). This form of lung cancer is typically a squamous cell carcinoma or adenocarcinoma involving the upper thoracic wall. Tumor extension to the paraspinal region and thoracic apex can involve the superior cervical ganglion of the sympathetic system and cause Horner syndrome (ptosis of the eyelid, pupil miosis, facial anhidrosis) (8). As with other nerves in the thorax, primary tumors of the nerves and nerve sheaths may also involve the sympathetic system (36–38). CT localization of the sympathetic nerves and ganglia is important in helping alleviate sympathetic symptoms in the upper limb such as hyperhidrosis or Raynaud disease (39).

## Costal Nerves

An intercostal nerve courses along the inferior edge of each of the first through 11th ribs. A subcostal nerve is located beneath each of the 12 ribs. These nerves innervate the muscles that join the ribs and provide sensory input from the overlying skin of the chest. (The first three intercostal nerves also mediate sensation from the upper extremities and axilla.) The costal nerves also refer sensation from the adjacent lower parietal pericardium, the parietal pleura, and the peripheral segment of the intrathoracic diaphragm (8). The subcostal nerves located under the 12th ribs along with the intercostal nerves from T6 to T12 innervate the muscles of the upper abdominal region and the overlying skin (5).

Trauma to an intercostal nerve caused by thoracotomy can lead to a loss of sensation in the skin overlying the injured nerve. When costal nerve damage is caused by tumor invasion, direct trauma, or rib fractures, patients may complain of chest wall pain or numbness. These symptoms can be alleviated with a costal nerve block (40–42). Herpes zoster can affect a single costal nerve, leading to pain and herpetic vesicles in the distribution of the nerve (8).

## Long Thoracic Nerves

The paired long thoracic nerves are symmetric and are present in every section of the thorax (Figs 1a, 1b, 2a, 3a, 4a–d). They do not have a sensory component but provide motor innervation to the anterior serratus muscle. Because they course along the midaxillary line of the lateral chest wall, trauma or surgery that damages this area results in an ipsilateral winged scapula (5). Repetitive trauma due to archery can also cause a palsy of the long thoracic nerve (43).

## Conclusions

Although the nerves of the thorax are rarely identified at cross-sectional imaging, their location can be inferred by localizing easily identified anatomic landmarks. Familiarity with the functional anatomy and clinical significance of these nerves is important for the correct interpretation of thoracic images.

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## References

1. Netter FH, Dalley AF, eds. Atlas of human anatomy. 2nd ed. East Hanover, NJ: Navartis, 1997.
2. Ellis H, Logan BM, Dixon AK. Thorax. In: Ellis H, Logan BM, Dixon AK, eds. Human sectional anatomy: atlas of body sections, CT and MRI images. 2nd ed. Oxford, England: Butterworth-Heinemann, 1999; 101–116.
3. Ledley RS, Huang HK, Mazziotta JC. Ledley RS, Huang HK, Mazziotta JC, eds. Cross-sectional anatomy: an atlas for computerized tomography. Baltimore, Md: Williams & Wilkins, 1977.
4. Rohen JW, Yokochi C, eds. Color atlas of anatomy. New York, NY: Igaku-Shoin, 1982.
5. Moore KL, Dalley AF. Clinically oriented anatomy. 4th ed. Philadelphia, Pa: Lippincott Williams & Wilkins, 1999; 685–689.
6. Taylor GA, Fishman EK, Kramer SS, Siegelman SS. CT demonstration of the phrenic nerve. J Comput Assist Tomogr 1983; 7:411–414.
7. Berkmen YM, Davis SD, Kazam E, Auh YH, Yankelevitz D, Girgis FG. Right phrenic nerve: anatomy, CT appearance, and differentiation from the pulmonary ligament. Radiology 1989; 173:43–46.
8. DeGowin RL. DeGowin & DeGowin's diagnostic examination. New York, NY: McGraw-Hill, 1994.
9. Lee KS, Im JG, Kim IY, Kim PN, Han MC, Kim CW. Tumours involving the intrathoracic vagus and phrenic nerves demonstrated by computed tomography: anatomical features. Clin Radiol 1991; 44:302–305.
10. Harker CP, Stern EJ, Frank MS. Hemidiaphragm paralysis: CT diagnosis. J Thorac Imaging 1994; 9:166–168.
11. Iverson LI, Mittal A, Dugan DJ, Samson PC. Injuries to the phrenic nerve resulting in diaphragmatic paralysis with special reference to stretch trauma. Am J Surg 1976; 132:263–269.

12. Eliraz A, Wishnitzer R, Mashiah A. Hiccup as a complication of displaced cardiac pacemaker electrode. Harefuah 1981; 100:335–336. [Hebrew]
13. Aggarwal S, Hari P, Bagga A, Mehta SN. Phrenic nerve palsy: a rare complication of indwelling subclavian vein catheter. Pediatr Nephrol 2000; 14: 203–204.
14. Dimopoulou I, Daganou M, Dafni U, et al. Phrenic nerve dysfunction after cardiac operations: electrophysiologic evaluation of risk factors. Chest 1998; 113:8–14.
15. Samsom M, Szarka LA, Camilleri M, Vella A, Zinsmeister AR, Rizza RA. Pramlintide, an amylin analog, selectively delays gastric emptying: potential role of vagal inhibition. Am J Physiol Gastrointest Liver Physiol 2000; 278:G946–G951.
16. Ringdahl EN. Vagally mediated atrial fibrillation in a young man. Arch Fam Med 2000; 9:389–390.
17. Pirmiecks A, Smith LF, Thorpe JA. Autonomic dysfunction in non-specific disorders of oesophageal motility. Eur J Cardiothorac Surg 2000; 17: 101–105.
18. Gilmer-Hill HS, Kline DG. Neurogenic tumors of the cervical vagus nerve: report of four cases and review of the literature. Neurosurgery 2000; 46: . 1498–1503.
19. Hoshino H, Ohbuchi T, Sakon O, et al. Intrathoracic neurofibroma originating in the left vagus nerve. Nihon Kokyuki Gakkai Zasshi 2000; 38: 54–58. [Japanese]
20. Miller RB, Boon MS, Atkins JP, Lowry LD. Vagal paraganglioma: the Jefferson experience. Otolaryngol Head Neck Surg 2000; 122:482–487.
21. Hirsch BE, Johnson JT, Black FO, Myers EN. Paraganglioma of vagal origin. Otolaryngol Head Neck Surg 1982; 90:708–714.
22. Conforti M, Rispoli P, Barile G, et al. Vagal paraganglioma: report of a case surgically treated and review of the literature. J Cardiovasc Surg (Torino) 2000; 41:99–103.
23. Lambert AW, Cosgrove C, Barwell J, Oxenham S, Wilkins DC. Vagus nerve stimulation: quality control in thyroid and parathyroid surgery. J Laryngol Otol 2000; 114:125–127.
24. Ekberg O, Lindgren S, Schultze T. Pharyngeal swallowing in patients with paresis of the recurrent nerve. Acta Radiol Diagn (Stockh) 1986; 27:697–700.
25. Yamamoto S, Masuda S, Okazaki T, Izumi H, Dambara T. A case report of neurinoma originating from the recurrent nerve. Nippon Kyobu Geka Gakkai Zasshi 1991; 39:2203–2207. [Japanese]
26. Chandawarkar RY, Kakegawa T, Fujita H, Yamana H, Hayabuthi N. Comparative analysis of imaging modalities in the preoperative assessment of nodal metastasis in esophageal cancer. J Surg Oncol 1996; 61:214–217.
27. Fenton JE, Timon CI, McShane DP. Recurrent laryngeal nerve palsy secondary to benign thyroid disease. J Laryngol Otol 1994; 108:878–880.
28. Hogg RP, Kuo MJ, Olliff J, Das GA. Invasion of the recurrent laryngeal nerve by adenoid cystic carcinoma: an unusual cause of true vocal fold paralysis. J Laryngol Otol 1999; 113:260–262.
29. Chijimatsu Y, Tajima J, Washizaki M, Homma H. Hoarseness as an initial manifestation of sarcoidosis. Chest 1980; 78:779–781.
30. Thompson RD, Empey DW, Bailey CM. Left recurrent nerve paralysis associated with complete lung collapse with consolidation in an adult with cystic fibrosis. Respir Med 1996; 90:567–569.
31. Caversaccio MD, Becker M, Zbaren P. Tracheal diverticulum presenting with recurrent laryngeal nerve paralysis. Ann Otol Rhinol Laryngol 1998; 107:362–364.
32. Delabrousse E, Clair C, Couvreur M, Clergeot-Grelier ML, Kastler B. Cervical aortic arch presenting with right recurrent palsy in an adult. J Radiol 2000; 81:542–544. [French]
33. Thirlwall AS. Ortner's syndrome: a centenary review of unilateral recurrent laryngeal nerve palsy secondary to cardiothoracic disease. J Laryngol Otol 1997; 111:869–871.
34. Chan P, Huang JJ, Yang YJ. Left vocal cord palsy: an unusual presentation of a mycotic aneurysm of the aorta caused by Salmonella cholerasuis. Scand J Infect Dis 1994; 26:219–221.
35. Shaw RR. Pancoast's tumor. Ann Thorac Surg 1984; 37:343–345.
36. Shin KH, Moon SH, Suh JS, Jahng JS. Multiple neurilemomas: a case report. Clin Orthop 1998; 171–175.
37. Farrelly C, Daneman A, Chan HS, Martin DJ. Occult neuroblastoma presenting with opsomyoclonus: utility of computed tomography. AJR Am J Roentgenol 1984; 142:807–810.
38. Fowler CL, Bloss RS. Hemangioma of a thoracic sympathetic ganglion mimicking a neuroblastoma. Pediatr Radiol 1994; 24:148–149.
39. Dondelinger RF, Kurdziel JC. Percutaneous phenol block of the upper thoracic sympathetic chain with computed tomography guidance. Acta Radiol 1987; 28:511–515.
40. Moore DC, Bush WH, Scurlock JE. Intercostal nerve block: a roentgenographic anatomic study of technique and absorption in humans. Anesth Analg 1980; 59:815–825.
41. Crossley AW, Hosie HE. Radiographic study of intercostal nerve blockade in healthy volunteers. Br J Anaesth 1987; 59:149–154.
42. Johnson LR, Rocco AG, Ferrante FM. Continuous subpleural-paravertebral block in acute thoracic herpes zoster. Anesth Analg 1988; 67:1105–1108.
43. Shimizu J, Nishiyama K, Takeda K, Ichiba T, Sakuta M. A case of long thoracic nerve palsy, with winged scapula, as a result of prolonged exertion on practicing archery. Rinsho Shinkeigaku 1990; 30:873–876. [Japanese]

# Thoracic Wall, Intercostal Muscles
# November 3, 2003

The thoracic cavity is an area that is protected by muscle and bone. A bony ribcage surrounds vascular structures (heart, lungs) and the area between the limbs is filled up by intercostals muscles. The ribcage is not a solid structure because this would prevent you from having any mobility. The thoracic cage, from the outside in, is covered in skin then superficial fascia then muscles for moving the upper limb (trapezius, serratus anterior, pectoralis mm).

**Thoracic cage**—The thoracic cage is composed of ribs that extend from the vertebral column posteriorly to the anterior portion of the body. **Ribs** can attach to the sternum. There are 12 pairs of ribs, each of which has **costal cartilages** associated with it. The first 7 ribs attach via costal cartilages directly to the sternum and are referred to as **true ribs**. Ribs 8-12 are referred to as **false ribs** because they do not have a direct attachment to the sternum. Of these ribs, numbers 8-10 are attached to the cartilage of the rib above. Ribs 11 and 12 are called **floating ribs**. They terminate in the muscles and do not have any connection at all to the sternum.

The typical parts of the rib are the head, neck, tubercle (an articulating point between the neck and shaft), shaft, costal angle (where the shaft spirals down and the rib curves), and the costal groove (there are nerves and vessels that run along here). The structure of the typical rib can be found in Moore's text on p. 62, figure 1-2. Most ribs articulate with two vertebrae posteriorly (except the top and bottom ribs). The ribs articulate by the costal cartilages with the sternum via **sternocostal joints**, synovial types of joints. Ribs assist in thoracic wall movement. The proximal end of the rib rotates to allow the distal end of the rib to swing. As a person inhales, the ribs swing out and up, making the thoracic cavity larger. As he or she exhales, the ribs swing back in and down. This is shown in Moore's text p. 70-71, figures 1.7 C and 1.8 A, but it should be noted that respiratory movements are also the result of many muscles. (Netter 178 A, B, 179B).

There are three main portions of the **sternum**. The **manubrium** is the superior most triangular bone. It is the widest and thickest of the bones of the sternum. On the upper portion of the manubrium is a concave border called the jugular notch (AKA suprasternal notch). The body of the sternum is below the manubrium. Their boundaries can be determined by the **sternal angle**, which is a projection (bump) on the sternum. This is the site where 2$^{nd}$ costal cartilages (of the 2$^{nd}$ rib pair) articulate with the sternum. This is important when counting ribs because the 2$^{nd}$ rib can be more easily seen and palpated than the first rib. Also, the sternal angle is also an important landmark dividing the plane of division of the thoracic cavity. It is found between the levels of T4 and T5. Lateral to the midline of the body of the sternum are the **costal arches**. These are the scalloped borders of the body. The third portion of the sternum is the **xiphoid process**. It is also an important landmark for other structures found in the thoracic area. (N 178 A, B)

The **thoracic vertebrae** are **characterized by** long, pointed spinous processes and costal facets. There is a costal facet located above the pedicle, one below the pedicle, and one

on the transverse process of each thoracic vertebrae. Typically, the head of a rib articulates with two vertebral bodies and the transverse process of the vertebrae below the rib. The rib number corresponds with the number of the vertebrae below it (Moore's text p. 66, figure 1-5).

**Muscles of the Thoracic Wall**—There are three layers of muscles found within the intercostal spaces of the ribcage. There are 11 intercostal spaces filled with these muscles. None of the muscles stretches the entire length of the intercostals space, but they overlap to collectively extend the entire length (Netter 183, 185A, Grant's Dissector figure 1-12).

> **External Intercostal muscles**—These muscles are closest to the surface. Their fibers angle toward the abdomen (remember this because when of the angle of your hand when it is in your front pants pocket). The **origin** of them is the inferior border of the rib above. They **insert** on the upper border of the rib below. Each is **innervated** by intercostal nerves and **supplied** by the intercostal artery. The external intercostal muscles extend posteriorly to the tip of the transverse processes. Anteriorly, they muscle fibers stop before reaching the lateral portion of the sternum, but their connective tissue structure, the **external intercostal membrane**, extends from the costochondral junction over to the lateral border of the sternum.
>
> **Internal Intercostal Muscles**—These muscles **originate** from the lateral border of the sternum. They continue posteriorly and **insert** as the intercostal membrane at the vertebral body. They are actually the same muscle as the innermost intercostal muscles. These two muscle layers are distinguished by the fact that the **intercostal nerve and artery passes between the two layers**. The fibers of these muscles run at a right angle to the external intercostal muscles. To remember this, think about the position of your hand when you place it in your back pocket.

The **primary function of the intercostal muscles** is to prevent the intercostal space from being stretched by inspiration and expiration. This prevents the intercostal space from blowing out or sucking in during respiration.

> **Tranzversus thoracis muscle**—This muscle is found on the underside of the sternum. Its origin is the posterior surface of the sternum. It inserts on the inner surfaces of costal cartilages 2-6 and is involved in respiration. It is innervated by costal nerves 2-6 and is supplied by the internal thoracic artery. (Netter 184)

**Innervation of the Thoracic Wall**—The thoracic wall has 12 pairs of spinal nerves that divide into ventral and dorsal primary rami. The ventral rami of T1-T11 form the **intercostal nerves** that run along the intercostal spaces. The ventral rami of T12 and beyond form the **subcostal nerves**.

The intercostal nerves branch into lateral cutaneous and anterior cutaneous branches. The **lateral cutaneous branches** pierce the internal and external muscles approximately

halfway around the thorax before dividing into anterior and posterior branches. The **anterior cutaneous branches** supply the skin on the anterior aspect of the thorax and abdomen (Netter 187).

The ribs prevent formation of nerve plexuses. This enables them to have a simple dermatome pattern of nerve supply ( a fairly segmental arrangement of dermatomes). This dermatome pattern can be seen in Moore's text, p. 86, figure 1-20 and Netter157.

**Vessels of the Thoracic Wall**—Typically, the blood vessels follow the nerves. Posteriorly, the **thoracic aorta** supplies the thoracic wall. It has posterior branches at each vertebral level, the **posterior intercostal arteries**. These cross the vertebral body and go into the intercostal spaces. There are also other branches of the thoracic aorta, including the *3rd right posterior intercostal artery* and the *costocervical trunk* (which supplies the first 2 intercostal spaces). (Netter 187, 233A, 165A)

The **internal thoracic artery** is located about ½ inch lateral to the edge of the sternum. It is on the deep side of the ribs and intercostal muscles and courses vertically. It also branches to give off **anterior intercostal arteries.** There are usually two anterior intercostal arteries per intercostal space which will anastamose with the posterior intercostal arteries (netter 184)

In the costal groove, the nerves and vessels lay between the internal and innermost intercostal muscles. Typically, the vein is located highest, the artery is intermediate, and the nerve is lowest ("VAN"). There may be variations in this VAN pattern, especially posteriorly (Moore's text p. 87, figure 1.21 B and Grant's dissector, figure 1.11)

**Thoracocentesis**—This involves the insertion of a hypodermic needle through the intercostal space and into the pleural cavity. This is typically done in the 9th intercostal space, in the middle so as not to damage the surrounding nerves and vessels. It is done to obtain a sample of fluid or to remove blood or pus (to remove something that shouldn't be there).

**Intercostal Nerve Block**—This involves the injection of a local anesthetic agent around the intercostal nerves.

**Endothoracic fascia**—This is a muscular investing facia found below the deepest layer of intercostal muscles. The endothoracic fascia holds the **parietal pleura** to the inner surface (Netter 188)

**Parietal Lymphatics in the Thorax**—The anterior thoracic wall has lymphatic drainage medially toward the sternum, specifically, to the **parasternal lymph nodes**. There are 1-2 of these nodes per intercostal space of the true ribs. Drainage also goes laterally and posteriorly to the **intercostal nodes** which drain directly to the thoracic duct or its beginning, the cysterna chili (Netter 235). Overall, the superficial lymphatics drain deep in reverse of the arterial blood flow, but in the same direction as venous blood flow of that region.

**Introduction to the Thoracic Cavity** (to be covered in tomorrow's lecture)—The **thoracic inlet** is the superior boundary of the thoracic cavity. It consists of the T1 vertebral body, the two first ribs and the manubrium of the sternum. Structures going into the thoracic inlet include the trachea and esophagus while structures coming out include vessels.

The **thoracic outlet** is the inferior border of the thoracic cavity. It consists of costal cartilages, the tips of the lower two ribs, and is filled in by the respiratory diaphragm.

The **walls of the thoracic cavity** are the sternum and costal cartilages anteriorly, the ribs (anteriorly, laterally, and posteriorly), and the vertebral bodies posteriorly.

The thoracic cavity **contains** respiratory, cardiac, and some digestive organs. These include the lungs, heart, esophagus, trachea and bronchi, great vessels, and nerves.

The cavity is divided into **three regions**: two pleural cavities which are completely filled by lung tissue and the mediastinum which contains the other components of the cavity (Netter 192).

**Clinical Correlates**

**Rib Fractures and Associated Injuries**—The 1$^{st}$ rib is rarely fractured because of its protected position, but when it is fractured, injury can occur to the brachial plexus and/or subclavian vessels. The middle ribs are the most commonly fractured ribs. Fractures are often due to direct blows or indirectly from crushing injuries. The weakest part of the rib is just anterior to its angle, but rib fractures can occur elsewhere. Fractures of the ribs can cause injury to internal organs (the lungs, spleen, etc). Rib fractures are painful because these parts must be moved during respiration. Rib pain may also be due to metastases of cancer. When a sizeable segment of the anterior or lateral chest wall moves freely because of multiple rib fractures, this is known as flail chest.

**Thoracotomy and Bone Grafting**—The surgical creation of an anterior opening into the thoracic wall is an anterior thoracotomy. Sometimes, pieces of rib are used for bone grafting procedures. The removal of pieces of ribs posteriorly is a posterior thoroacotomy. This is often done in order to enter the thoracic cavity.

**Supernumerary Ribs**—Sometimes there are cervical or lumbar ribs present or a failure of the 12$^{th}$ rib pair to form. Supernumerary ribs result from the retention and development of the costal processes of the cervical and lumbar vertebrae. For details on individual ribs, see p. 64-65 in Moore's.

**Protective Function and Variation of Costal Cartilages**—The costal cartilages prevent many blows from fracturing the sternum and/or ribs. In kids, the ribs and costal cartilages are very elastic, so a chest compression injury can occur even though there is no rib fracture. In the elderly, the costal cartilages can become brittle and may undergo calcification.

**Effect of an Aortic Aneurysm on Vertebrae**—When the aorta develops an aneurysm, the bodies of the thoracic vertebrae T5-T8 may be eroded by the pressure from the aneurysm.

**Bony Xipoid Processes**—People often begin to detect their partly ossified xiphoid processes (often in early 40s) and contact their physician about hard lumps in the pits of their stomach.

**Sternal Fractures**—Fractures of the sternum are uncommon. Crush injuries can occur after trauma (ex. due to an automobile accident where the driver's chest is forced into the steering column). The number of sternal fractures has been reduced by installation of airbags in vehicles. A fracture of the sternal body is usually a comminuted one in which the sternum is broken into pieces. The most common site of a sternal fracture is at the sternal angle. This results in a dislocation of the manubriosternal joint.

**Median Sternotomy**—This involves splitting the sternum in the median plane to give good exposure to the chest cavity for operations, such as coronary artery bypass grafting and removal of lung tumors. After surgery, the halves are rejoined with wire sutures.

**Sternal Biopsies**—The sternum is often used to perform bone marrow biopsies because of its subcutaneous position and breadth. This type of biopsy is often used to obtain specimens of bone marrow for transplantations or detection of metastatic cancers.

**Sternal Anomalies**—Sometimes there is defective ossification of the sternum (develops as segments that normally unite). Severe clefts formed by defective ossification are rare. Sometimes there is a perforation in the sternal body because of faulty ossification. This is not clinically significant, but is something a physician must be aware of so as not to confuse it with some other finding.

**Dislocation of the Ribs**—A dislocation of the rib is the displacement of the costal cartilage from the sternum or the dislocation of an interchondral joint. Dislocations are common in contact sports and can produce pressure or damage to nearby nerves, muscles, or vessels.

**Separation of Ribs**—A rib separation refers to a dislocation of the costochondral junction. This usually involves a tearing of the perichondrium and periosteum. The rib may move superiorly overriding the rib above it and causing pain.

**Paralysis of the Diaphragm**—Paralysis of ½ of the diaphragm due to injury of the phrenic nerve does not affect the other half b/c each dome of the diaphragm has a different nerve supply. Paralysis can be noted by observing the movement of the chest during respiration.

**Thoracic Outlet Syndrome**—There are various types of this that exist. The costoclavicular syndrome results from compression of the subclavian artery between the clavicle and 1$^{st}$ rib and is characterized by pallor and coldness of the skin of the upper

limb along with diminished radial pulse. The cervical rib syndrome results from compression of C8 and T1 nerve roots and the inferior trunk of the brachial plexus.

**Dyspnea**—This is difficulty breathing. Patients who have respiratory problems often struggle to breathe and must use their accessory respiratory muscles to assist the expansion of their thoracic cavities.

**Herpes Zoster Infection**—An infection which causes a dermatomally distributed lesion called shingles. Herpes zoster is a viral disease of the spinal ganglia that invades the ganglia and then produces a sharp burning pain in the dermatome supplied by the involved nerve. The area that is affected will become red and will have vesicular eruptions on it. Muscle weakness may occur in some people; it will occur along the same myotomal distribution as the dermatomal pain and vesicular eruptions.

# Chapter 20: The thoracic wall and mediastinum



## Thoracic wall

### *Muscles*

**The muscles of the thoracic and abdominal walls are in general arranged in external, middle, and internal layers. In the thorax (figs. 20-1 and 20-2), these are the (1) external intercostal muscles, (2) internal intercostal muscles, and (3) innermost intercostal muscles, subcostal muscles, and transversus thoracis. The internal layer and the thoracic skeleton are separated from the costal pleura by the endothoracic fascia. The diaphragm separates the thoracic and abdominal viscera.**

**The external intercostal muscles.**

**The external intercostal muscles are attached to the lower margins of ribs 1 to 11. Their fibers pass inferior and anterior to insert on the upper margin of the rib below. Anteriorly, at the costochondral junctions, the external intercostal muscles are replaced by the external intercostal membranes (fig. 20-2). The muscles are supplied by the corresponding intercostal nerves. They elevate the ribs and hence are considered to be muscles of inspiration. They are assisted posteriorly by the levatores costarum, which run from the transverse processes to the backs of the subjacent ribs and are supplied by primary dorsal rami.**

**The internal intercostal muscles.**

The internal intercostal muscles are attached to the lower margins of the ribs and costal cartilages and to the floor of the costal groove. Their fibers pass inferior and posterior to insert on the upper margin of the rib and costal cartilage below. Posteriorly, at the angles of the ribs, the internal intercostal muscles are replaced by the internal intercostal membranes (fig. 20-2). The muscles are supplied by the corresponding intercostal nerves. For the most part, they are muscles of expiration.

The innermost intercostal muscles.

The innermost intercostal muscles may be regarded as those parts of the internal intercostal muscles that are internal to the intercostal vessels and nerves. Their action is unknown. The subcostal muscles, which are quite variable, arise from the ribs posteriorly and are inserted into the second or third rib below. They probably elevate the ribs. The transversus thoracis (or sternocostalis) (see fig. 19-2) arises from the posterior surface of the xiphoid process and body of the sternum and is inserted posteriorly into several costal cartilages. It appears to be expiratory in function. All these muscles are supplied by the corresponding intercostal nerves.

The diaphragm.

The diaphragm, is the most important muscle of respiration. It separates the thoracic and abdominal viscera. Three of its parts (sternal, costal, and lumbar) are inserted into the central tendon, a trifoliate structure that lies immediately inferior to the heart. The sternal part consists of slips from the xiphoid process, which (in vivo) descend to the central tendon. On each side, a small gap known as the sternocostal triangle is present between the sternal and costal parts. It transmits the superior epigastric vessels and some lymphatics, and it may be the site of a diaphragmatic hernia. The costal parts, which form the right and left "domes," arise from the inner surfaces of the lower costal cartilages and ribs and interdigitate with the transversus abdominis. They are inserted into the central tendon anterolaterally. Each lumbar (or vertebral) part arises from (1) a lateral arcuate ligament over the quadratus lumborum, (2) a medial arcuate ligament over the psoas major, and (3) a crus from the upper lumbar vertebrae (see fig. 25-13B). Usually the right crus arises from the first to third (or fourth) lumbar vertebrae (L1 to 3 or 1 to 4) and the left from L.V.1 to 2 or 1 to 3. The crura are united anterior to the aorta by the median arcuate ligament, a fibrous arch that forms the aortic opening. The

right crus splits around the esophagus (see figs. 21-2 and 25-13B), and part of it continues into the suspensory ligament of the duodenum. The left crus is smaller and more variable.

The diaphragm has three major openings (see fig. 25-13B). The esophageal opening in the right crus transmits the esophagus and vagus nerves. The aortic opening lies posterior to the crura and transmits the aorta, the thoracic duct and greater splanchnic nerves, and occasionally the azygos vein. The foramen for the inferior vena cava, in the right half of the central tendon, transmits the vena cava, right phrenic nerve, and lymphatic vessels. Other structures that pierce or are related to the diaphragm include the splanchnic nerves, sympathetic trunk, subcostal nerves and vessels, superior epigastric and musculophrenic vessels, and azygos and hemiazygos veins.

The portion of the costal part of the diaphragm that arises from ribs 11 and 12 is often separated from the lumbar part by an interval termed the vertebrocostal trigone (see fig. 25-13B). Such a triangle is occupied by connective tissue that separates the pleura above from the suprarenal gland and upper pole of the kidney below.

Variations in the degree of development of the muscular parts are not uncommon. Congenital diaphragmatic hernia, whereby an abdominal organ may enter the thoracic cavity, may occur through the esophageal opening (hiatal hernia), through a gap in the costal part of the diaphragm (e.g., from a persistent pleuroperitoneal canal), or through the sternocostal triangle. Diaphragmatic herniae usually have peritoneal sacs.

The diaphragm, together with the adjacent pleura and peritoneum, is supplied by the phrenic nerves (see fig. 24-6), each of which is distributed to one half of the diaphragm. Although the two halves usually contract synchronously, paralysis of one half does not affect the other half, because each half of the diaphragm has a separate innervation. The diaphragm is under only limited voluntary control. Hiccups are sharp, spasmodic contractions of the diaphragm. The peripheral portion of the diaphragm is supplied with sensory and vasomotor fibers from the intercostal nerves.

The diaphragm descends when it contracts. The volume of the thorax is thereby increased, whereas intrathoracic pressure is decreased; the converse holds for the abdominal cavity. The decreased intrathoracic pressure and increased abdominal pressure that accompany descent of the diaphragm facilitate the return of blood to the heart.

When a subject is in the erect position and the midphase of respiration, the summit of the domes of the diaphragm is at about the same level as the apical region of the heart (fifth intercostal space; rib 6; or thoracic vertebral body T10 or 11). The right dome of the diaphragm is commonly about 1 cm higher than the left. During quiet breathing, the diaphragm undergoes an excursion of about 1/2 cm, whereas, during deep breathing, the excursion may be as much as 10 cm.

*Thoracic nerves*

Each of the 12 thoracic (spinal) nerves gives off a meningeal branch, emerges from an intervertebral foramen, and divides into a dorsal and a ventral ramus. These rami contain motor fibers to muscles, sensory fibers from skin and deep tissues, and postganglionic sympathetic fibers to blood vessels, sweat glands, and arrector pili muscles (fig. 20-4).

The dorsal primary rami (figs. 20-2 and 20-4) pass posteriorward and supply the bones, joints, muscles, and skin of the mid-back. The ventral primary rami run anteriorward and supply the serous membranes, muscles, and skin of the thoracic and abdominal walls. Each is connected to the sympathetic trunk by a variable number of rami communicantes (figs. 20-3 and 20-4). Although the distribution of the ventral rami issegmental, overlap of adjacent nerves is so great that section of three consecutive nerves would be necessary to produce complete anesthesia and paralysis within the middle one of the three intercostal spaces supplied.

The ventral primary rami of the first 11 thoracic (spinal) nerves are called intercostal nerves, whereas that of the twelfth is subcostal. Ventral rami 1 to 3 contribute to the upper limb as well as to the thoracic wall, and ventral rami 7 to 12 are thoraco-abdominal in their distribution. Intercostal nerves can be "blocked" posteriorly by a local anesthetic, e.g., for pain after fracture of a rib.

Intercostal nerves.

Intercostal nerves 4 to 6 are "typical" (figs. 20-1, 20-3 and 20-4) in that they supply only the thoracic wall and its associated muscles (intercostal, subcostal, serratus posterior superior, and transversus thoracis). Each passes inferior to the neck of the corresponding rib and enters the costal groove. In its course anteriorward, it lies first on the pleura and endothoracic fascia, then between the innermost and internal intercostal muscles, and finally on the transversus thoracis and internal thoracic vessels. At the anterior end of the intercostal space, it passes through the internal intercostal muscle, external intercostal membrane, and pectoralis major, to be distributed as the anterior cutaneous branch to the anterior chest. Each intercostal nerve gives off a collateral branch to the inferior part of the intercostal space and a lateral cutaneous branch to the side of the chest. In addition to being distributed to muscle and skin, branches are given to the parietal pleura, mammary gland, and periosteum of the ribs.

The first thoracic nerve divides into a superior part, which joins the brachial plexus, and an inferior part, which

becomes the first intercostal nerve (fig. 20-5). The lateral cutaneous branches of intercostal nerves 1 to 3 contribute to the upper limb, that of the second being known as the intercostobrachial nerve.

Intercostal nerves 7 to 11 supply the abdominal as well as the thoracic wall; hence they may be termed thoraco-abdominal (see fig. 25-12). At the anterior end of the intercostal spaces, they pass between the muscles of the abdominal wall and come to lie between the rectus abdominis and the posterior wall of its sheath. Here each nerve divides into branches that supply the rectus and the overlying skin. Their lateral cutaneous branches also contribute to the abdominal wall. The thoraco-abdominal nerves give branches to thoracic and abdominal muscles and skin and sensory twigs to the pleura, diaphragm, and peritoneum.

The ventral ramus of thoracic nerve 12 is known as the subcostal nerve. It enters the abdomen posterior to the lateral arcuate ligament, crosses posterior to the kidney, penetrates the muscles of the abdominal wall, enters the rectus sheath, and becomes cutaneous (see fig. 25-12).

*Blood vessels and lymphatic drainage*

The thoracic wall is supplied by branches of (1) the subclavian artery (internal thoracic and highest intercostal arteries), (2) the axillary artery, and (3) the aorta (posterior intercostal and subcostal arteries).

The internal thoracic.

The internal thoracic artery (previously called the internal mammary) artery (fig. 19-2) arises from the first part of the subclavian artery. It descends posterior to the sternomastoid muscle, clavicle, and subclavian and internal jugular veins. It is crossed by the phrenic nerve, and it lies on the pleura. It then descends posterior to the upper six costal cartilages, immediately lateral to the sternum, and anterior to the pleura. It gives branches to the intercostal spaces, pleura, pericardium, and breast. At the sixth intercostal space, it divides into the superior epigastric and musculophrenic arteries. The superior epigastric artery traverses the sternocostal triangle of the diaphragm, descends between the rectus abdominis and the posterior layer of its sheath, and anastomoses with the inferior epigastric artery. The musculophrenic artery, more laterally placed, supplies several intercostal spaces, pierces the diaphragm, and anastomoses with the deep circumflex iliac artery.

Posterior intercostal arteries.

Posterior intercostal arteries 1 and 2 arise from the highest intercostal artery, which is a branch of the costocervical trunk of the subclavian artery. Posterior intercostal arteries 3 to 11 arise from the aorta (figs. 20-2 and 20-3). The right-sided arteries are longer because they have to cross the vertebral column. They lie posterior to the pleura, azygos venous system, and sympathetic trunk. Each artery enters the costal groove, runs forward between the vein and nerve ("V.A.N.") (between the innermost and internal intercostals muscles), and anastomoses with branches of the internal thoracic or musculophrenic arteries. A lateral cutaneous branch accompanies the corresponding nerve. The two subcostal arteries are in series with the intercostal arteries, and they enter the abdomen with the corresponding nerves.

The anastomoses between the internal thoracic, posterior intercostal, and inferior epigastric arteries provide an important collateral circulation in obstruction of the aorta, e.g., from coarctation. In such instances, the enlarged intercostal arteries in the costal grooves may erode the bone and show radiographically as notching of the ribs.

The parietal lymph nodes of the thorax are the parasternal, phrenic, and intercostal. The parasternal nodes, situated along the upper part of the internal thoracic artery, receive lymphatics from the medial part of the breast, the intercostal spaces, the costal pleura, and the diaphragm and drain into the bronchomediastinal trunk. The parasternal nodes allow the spread of carcinoma of the breast to the lungs and mediastinum and, by way of the diaphragm, even downward to the liver. The phrenic nodes are situated on the thoracic surface of the diaphragm. They receive lymphatics from the pericardium, diaphragm, and liver and drain into the parasternal nodes. Intercostal nodes are found at the vertebral end of the intercostal spaces.

*Joints*

The joints of the thorax occur between (1) vertebrae, (2) ribs and vertebrae, (3) ribs and costal cartilages, (4) costal cartilages, (5) costal cartilages and the sternum, and (6) the parts of the sternum.

The costovertebral joints (figs. 20-3 and 20-6), synovial in type, are those of the heads of the ribs and the costotransverse joints. The head (n) of a typical rib (ribs 2 to 9) articulates with the inferior and superior costal facets of two adjacent vertebral bodies (n-1 and n) and the intervening intervertebral disc. The heads of ribs 1 and 10 to 12 articulate with only one vertebra each; The tubercle of a typical rib forms a costotransverse joint with the costal facet on the transverse process of the corresponding vertebra. These joints are absent in ribs 11 and 12.

The costochondral joints are hyaline cartilaginous joints between the ends of the costal cartilages and ribs. The interchondral joints, generally synovial, are between costal cartilages 5 to 8 or 5 to 9.

The sternocostal (or sternochondral) joints, often considered synovial, are between costal cartilages 1 to 7 and the lateral margin of the sternum. The manubriosternal joint is fibrocartilaginous but may become ossified. The xiphosternal joint is cartilaginous but later becomes ossified.

*Movements of thoracic cage*

The numerous thoracic joints are subject to continual movement, and any disorder that reduces their mobility hampers respiration.

In general, the ribs move around two axes. Movement at costovertebral joints 2 to 6 about a side-to-side axis results in raising and lowering the sternal end of the rib, the "pump-handle" movement (fig. 20-7). The downward slope of the rib ensures that, in elevation, the sternum moves upward and forward, increasing the anteroposterior diameter of the thorax. Movement at costovertebral joints 7 to 10 about an anteroposterior axis results in raising and lowering the middle of the rib, the "bucket-handle" movement (fig. 20-7). In elevation, this increases the transverse diameter of the thorax.

A movement of only a few millimeters is sufficient to increase the volume of the thoracic cage by the usual volume of air that enters and leaves the lungs during quiet breathing. In deep breathing the excursions are greater. The descent of the diaphragm increases the height of the thoracic cavity and hence increases the volume of the thorax. However, in unilateral or even bilateral paralysis of the diaphragm, there may be no significant disability. Diaphragmatic breathing is often called abdominal (as distinct from thoracic) breathing.

The diaphragm, whose descent increases the volume of the thoracic cavity, is the most important muscle of respiration. The mechanical actions of the intercostal muscles are not fully understood, but the external intercostal muscles (and intercartilaginous parts of the internal intercostal muscles) probably elevate the ribs and thus are inspiratory in function. The interosseous portions of the internal intercostal muscles probably depress the ribs and are thus expiratory in function.

In the inspiratory phase of quiet breathing, the diaphragm, "parasternal" intercostal muscles, and external intercostal muscles posteriorly are active, and, in some people, so are the scalene muscles. Expiration is mainly passive,

because of the elasticity of the lungs, but the interosseous internal intercostal muscles of the lower interspaces also contribute. When breathing becomes deeper, the sternocleidomastoids and extensors of the vertebral column are active near the end of inspiration. Moreover, the external abdominal muscles anterolaterally become increasingly active during expiration. These muscles draw the ribs down and are the most important expiratory muscles. They compress the abdominal viscera and are active in coughing, straining, and vomiting. Muscular control of expiration is important in speaking and singing.

## Mediastinum

The mediastinum is defined as the interval between the two pleural sacs. It is commonly considered to comprise a superior mediastinum, above the level of the pericardium, and three lower divisions: anterior, middle, and posterior. Figure 20-8 shows the arrangement in vivo.

The anterior mediastinum. between the sternum and pericardium, contains the thymus. The middle mediastinum contains the pericardium, heart, and the main bronchi and other structures of the roots of the lungs. The posterior mediastinum, behind the pericardium, contains the esophagus and thoracic aorta. The superior mediastinum contains the thymus, great vessels related to the heart, the trachea, and the esophagus. The mediastinum contains various groups of visceral lymph nodes. The various structures in the mediastinum are surrounded and supported by loose connective tissue often infiltrated with fat.

## Additional reading

Campbell, E. J. M., Agostoni, E., and Davis, J. N., The Respiratory Muscles. 2nd ed., Lloyd-Luke, London, 1970. A detailed account of respiratory mechanics and neural control.

## Questions

20-1 What is the action of the diaphragm in respiration?

20-2 What is the vertebrocostal trigone?

20-3 Where may a congenital diaphragmatic hernia be found?

20-4 Which nerves are (a) intercostal, (b) subcostal, (c) thoraco-abdominal?

20-5 What does notching of ribs seen radiographically suggest?

20-6 What is the mediastinum?

## Figure legends

**Figure 20-1 The intercostal muscles. A shows the direction of fibers of the external and internal intercostal muscles. B shows a vertical section through an intercostal space. The white arrow represents the path of a needle in pleural aspiration, avoiding the intercostal vessels and nerve.**

**Figure 20-2 The nerves, arteries, and muscles of the thoracic wall. Note that the intercostal vessels pass behind the longitudinally disposed structures of the posterior mediastinum. The thickness of the intercostal muscles is exaggerated.**

**Figure 20-3 Intercostal vessels and nerve. A part of the sympathetic trunk is shown, including some rami communicantes.**

**Figure 20-4 Functional components of a thoracic nerve. For purposes of simplification, each component is shown as a single fiber. Motor fibers to skeletal muscle are shown in red, sympathetic fibers in black, and sensory fibers in blue. The branches of the ventral ramus to the pleura and peritoneum are not shown.**

**Figure 20-5 The ventral ramus of the first thoracic nerve, viewed from below. Note how the upper division of T1 joins C8 and forms the lower trunk of the brachial plexus, which rests on the first rib. Part of the sympathetic trunk is shown. The cervicothoracic ganglion is tightly bound to the first thoracic nerve by rami communicantes, but these lie posteriorly and are hidden.**

**Figure 20-6 The costovertebral joints viewed from (A) above and (B) behind.**

**Figure 20-7 Diagram of certain movements of the ribs. In A, when the upper ribs are elevated, the anteroposterior diameter of the thorax is increased ("pump-handle" movement). In B, the lower ribs move laterally when they are elevated, and the transverse diameter of the thorax is increased ("bucket-handle" movement).**

**Figure 20-8 The divisions of the mediastinum. It should be stressed that the boundaries shown here are those in vivo, with the subject erect. See also figs. 22-4 and 22-5.**

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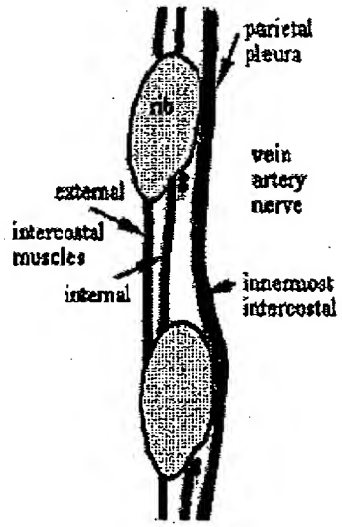
# An Intercostal Space

## The intercostal muscles

The space between adjacent ribs, the intercostal space is filled in by the intercostal muscles. The external intercostal muscle fibres run downwards and forwards from the rib above to the rib below. Anteriorly the muscle fibres are replaced by the anterior intercostal membrane. The internal intercostal muscle fibres lie inside the externals and run downwards and backwards between adjacent ribs, lying behind the anterior intercostal membrane and forming the posterior intercostal membrane posteriorly. The innermost intercostals form a layer internal to the internal intercostals. Muscle fibres of this layer form an incomplete sheet. The muscle fibres of this layer cross more than one intercostal space. Anteriorly the muscle fibres form the transversus thoracis muscles. Posteriorly they form the subcostal muscles.

## The neurovascular bundle



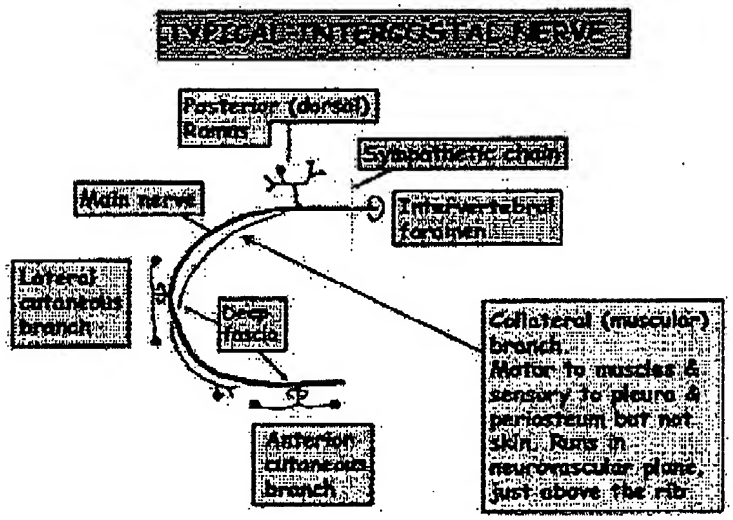

Lying between the innermost and the inner intercostal muscles is the neurovascular bundle . Each intercostal space receives an anterior primary ramus of a spinal nerve. The intercostal nerve supplies the muscles of the space, the pleura lining the chest wall, and by lateral and anterior cutaneous branches supplies the skin. The nerves are mixed nerves. Posteriorly the posterior intercostal arteries gain access to the neurovascular plane and curve around laterally at the lower border of the rib. Anteriorly a pair of small anterior intercostal arteries runs in the neurovascular plane of each space. The anterior intercostal arteries arise from the internal thoracic (mammary) artery and form anastomoses with the posterior intercostal arteries which arise from the thoracic aorta. The upper two intercostal spaces are above the level of the thoracic aorta and receive their supply from the costocervical trunk. The veins from the intercostal spaces drain backwards to the azygos venous system (see azygos veins in cardiovascular menu). On the right side the azygos vein collects intercostal veins from all of the intercostal spaces except the first, and by the hemiazygos and accessory hemiazygos veins from all of the intercostal spaces on the left except for the upper three spaces. The first intercostal space on the right drains to the right brachiocephalic vein. The upper three intercostal spaces on the left drain into the left brachiocephalic vein. Valves in the intercostal veins direct

blood towards the azygos vein. The anterior intercostal spaces drain anteriorly to the internal thoracic veins.

## Applied anatomy

Under certain circumstances it is necessary to introduce a drain through an intercostal space. The neurovascular bundle should be avoided. This can be accomplished by passing the drain through the intercostal space just above the upper border of the rib.

Return to Thorax



Henry Gray (1821–1865). Anatomy of the Human Body. 1918.

## 6c. The Thoracic Nerves

### (NN. Thoracales)

The **anterior divisions of the thoracic nerves** (*rami anteriores; ventral divisions*) are twelve in number on either side. Eleven of them are situated between the ribs, and are therefore termed **intercostal;** the twelfth lies below the last rib. Each nerve is connected with the adjoining ganglion of the sympathetic trunk by a gray and a white ramus communicans. The intercostal nerves are distributed chiefly to the parietes of the thorax and abdomen, and differ from the anterior divisions of the other spinal nerves, in that each pursues an independent course, *i. e.,* there is no plexus formation. The first two nerves supply fibers to the upper limb in addition to their thoracic branches; the next four are limited in their distribution to the parietes of the thorax; the lower five supply the parietes of the thorax and abdomen. The twelfth thoracic is distributed to the abdominal wall and the skin of the buttock.

**The First Thoracic Nerve.**—The anterior division of the first thoracic nerve divides into two branches: one, the larger, leaves the thorax in front of the neck of the first rib, and enters the brachial plexus; the other and smaller branch, the **first intercostal nerve,** runs along the first intercostal space, and ends on the front of the chest as the first anterior cutaneous branch of the thorax. Occasionally this anterior cutaneous branch is wanting. The first intercostal nerve as a rule gives off no lateral cutaneous branch; but sometimes it sends a small branch to communicate with the intercostobrachial. From the second thoracic nerve it frequently receives a connecting twig, which ascends over the neck of the second rib.

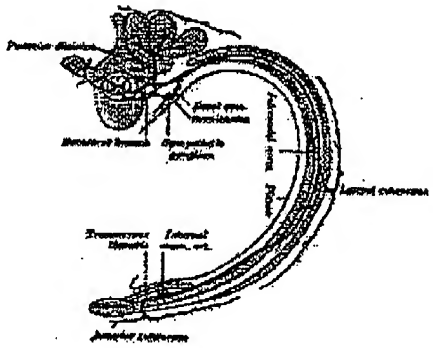


FIG. 819– Diagram of the course and branches of a typica intercostal nerve. (See enlarged image)

**The Upper Thoracic Nerves (*nn. intercostales*).**—The anterior divisions of the second, third, fourth, fifth, and sixth thoracic nerves, and the small branch from the first thoracic, are confined to the parietes of the thorax, and are named **thoracic intercostal nerves.** They pass forward (Fig. 819) in the intercostal spaces below the intercostal vessels. At the back of the chest they lie between the pleura and the posterior intercostal membranes, but soon pierce the latter and run between the two planes of Intercostal muscles as far as the middle of the rib. They then enter the substance of the Intercostales interni, and, running amidst their fibers as far as the costal cartilages, they gain the inner surfaces of the muscles and lie between them and the pleura. Near the sternum, they cross in front of the internal mammary artery and Transversus thoracis muscle, pierce the Intercostales interni, the anterior intercostal membranes, and Pectoralis major, and supply the integument of the front of the thorax and over the mamma, forming the anterior cutaneous branches of the thorax; the branch from the second nerve unites with the anterior supraclavicular nerves of the cervical plexus. 3

**Branches.**—Numerous slender muscular filaments supply the Intercostales, the Subcostales, the Levatores costarum, the Serratus posterior superior, and the Transversus thoracis. At the front of the thorax some of these branches cross the costal cartilages from one intercostal space to another. 4

**Lateral cutaneous branches** (*rami cutanei laterales*) are derived from the intercostal nerves, about midway between the vertebræ and sternum; they pierce the Intercostales externi and Serratus anterior, and divide into anterior and posterior branches. The **anterior branches** run forward to the side and the forepart of the chest, supplying the skin and the mamma; those of the fifth and sixth nerves supply the upper digitations of the Obliquus externus abdominis. The **posterior branches** run backward, and supply the skin over the scapula and Latissimus dorsi. 5

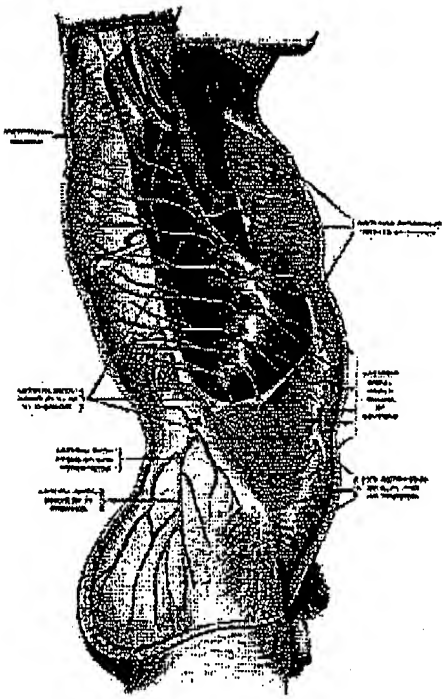


FIG. 820– Cutaneous distribution of thoracic nerves. (Testut.) (See enlarged image)

The lateral cutaneous branch of the second intercostal nerve does not divide, like the others, into an anterior and a posterior branch; it is named the **intercostobrachial nerve** (Fig. 816). It pierces the Intercostalis externus and the Serratus anterior, crosses the axilla to the medial side of the arm, and joins with a filament from the medial brachial cutaneous nerve. It then pierces the fascia, and supplies the skin of the upper half of the medial and posterior part of the arm, communicating with the posterior brachial cutaneous branch of the radial nerve. The size of the intercostobrachial nerve is in inverse proportion to that of the medial brachial cutaneous nerve. A second intercostobrachial nerve is frequently given off from the lateral cutaneous branch of the third intercostal; it supplies filaments to the axilla and medial side of the arm.

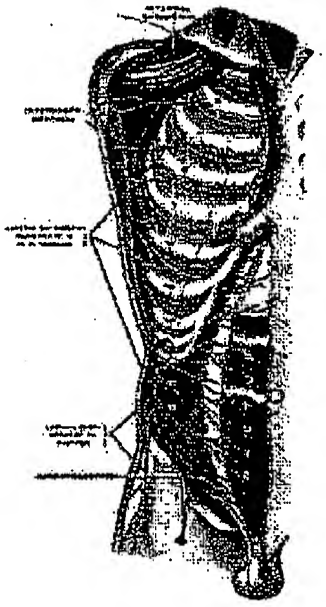


FIG. 821– Intercostal nerves, the superficial muscles having been removed. (Testut). (See enlarged image)

**The Lower Thoracic Nerves.**—The anterior divisions of the seventh, eighth, ninth, tenth, and eleventh thoracic nerves are continued anteriorly from the intercostal spaces into the abdominal wall; hence they are named **thoracicoabdominal intercostal nerves.** They have the same arrangement as the upper ones as far as the anterior ends of the intercostal spaces, where they pass behind the costal cartilages, and between the Obliquus internus and Transversus abdominis, to the sheath of the Rectus abdominis, which they perforate. They supply the Rectus abdominis and end as the **anterior cutaneous branches** of the abdomen; they supply the skin of the front of the abdomen. The lower intercostal nerves supply the Intercostales and abdominal muscles; the last three send branches to the Serratus posterior inferior. About the middle of their course they give off **lateral cutaneous branches.** These pierce the Intercostales externi and the Obliquus externus abdominis, in the same line as the lateral cutaneous branches of the upper thoracic nerves, and divide into anterior and posterior branches, which are distributed to the skin of the abdomen and back; the anterior branches supply the digitations of the Obliquus externus abdominis, and extend downward and forward nearly as far as the margin of the Rectus abdominis; the posterior branches pass backward to supply the skin over the Latissimus dorsi.

The anterior division of the **twelfth thoracic nerve** is larger than the others; it runs along the lower border of the twelfth rib, often gives a communicating branch to the first lumbar nerve, and passes under the lateral lumbocostal arch. It then runs in front of the Quadratus lumborum, perforates the Transversus, and passes forward between it and the Obliquus internus to be distributed in the same manner as the lower intercostal nerves. It communicates with the iliohypogastric nerve of the lumbar plexus, and gives a branch to the Pyramidalis. The **lateral cutaneous branch** of the last thoracic nerve is large, and does not divide into an anterior and a posterior branch. It perforates the Obliqui internus

and externus, descends over the iliac crest in front of the lateral cutaneous branch of the iliohypogastric (Fig. 819), and is distributed to the skin of the front part of the gluteal region, some of its filaments extending as low as the greater trochanter.

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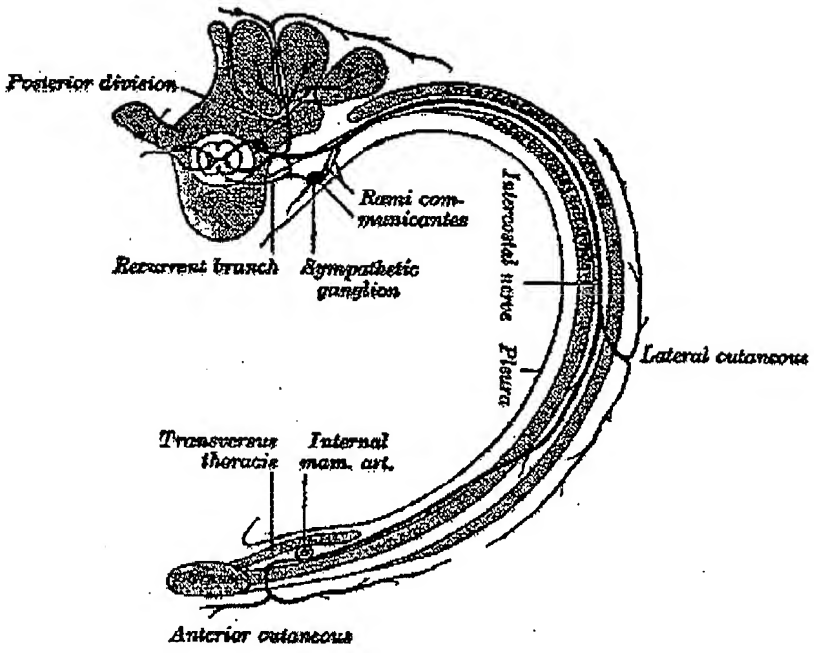
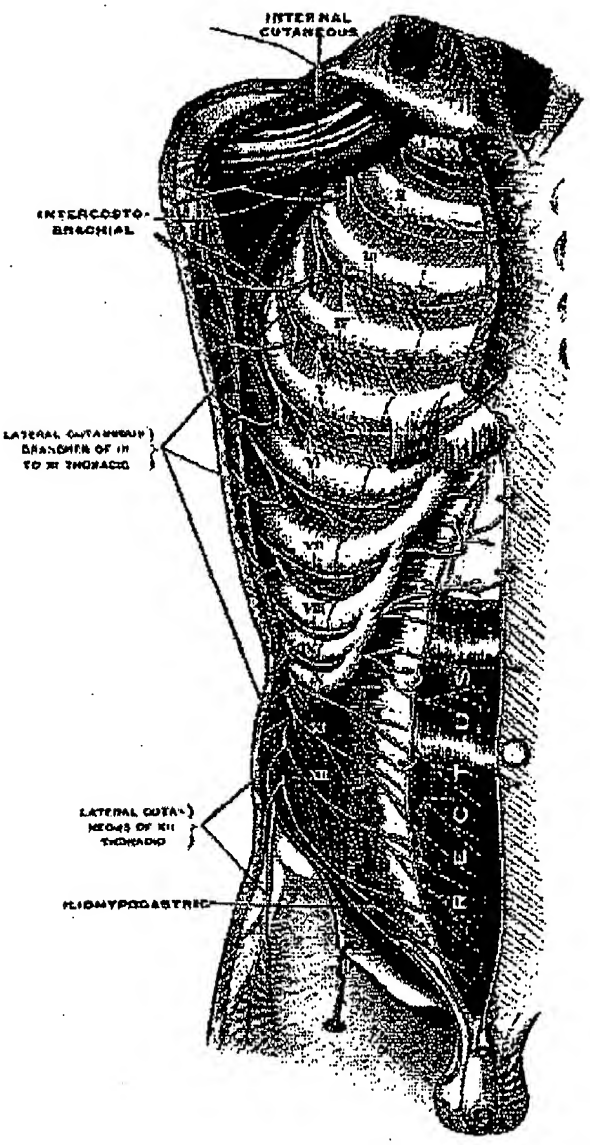
# Intercostal nerves

From Wikipedia, the free encyclopedia

**http://en.wikipedia.org/wiki/Intercostal_nerves**

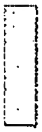





The **intercostal nerves** are the anterior divisions (rami anteriores; ventral divisions) of the thoracic spinal nerves from T1 to T11.

Each nerve is connected with the adjoining ganglion of the sympathetic trunk by a gray and a white ramus communicans. The intercostal nerves are distributed chiefly to the thoracic pleura and abdominal peritoneum, and differ from the anterior divisions of the other spinal nerves, in that each pursues an independent course without plexus formation.

The first two nerves supply fibers to the upper limb in addition to their thoracic branches; the next four are limited in their distribution to the parietes of the thorax; the lower five supply the parietes of the thorax and abdomen. The 7th intercostal nerve terminates at the xyphoid process, at the lower end of the sternum. The 10th intercostal nerve terminates at the umbilicus. The twelfth (subcostal) thoracic is distributed to the abdominal wall and groin.



## The 1st Thoracic Nerve

The anterior division of the first thoracic nerve divides into two branches: one, the larger, leaves the thorax in front of the neck of the first rib, and enters the brachial plexus; the other and smaller branch, the first intercostal nerve, runs along the first intercostal space, and ends on the front of the chest as the first anterior cutaneous branch of the thorax.

Occasionally this anterior cutaneous branch is missing.

The first intercostal nerve rarely gives off a lateral cutaneous branch; but sometimes sends a small branch to communicate with the intercostobrachial.

From the second thoracic nerve it frequently receives a connecting twig, which ascends over the neck of the second rib.

## The Upper Thoracic Nerves: 2nd-6th

The anterior divisions of the second, third, fourth, fifth, and sixth thoracic nerves, and the small branch from the first thoracic, are confined to the parietes of the thorax, and are named thoracic intercostal nerves.

They pass forward in the intercostal spaces below the intercostal vessels. At the back of the chest they lie between the pleura and the posterior intercostal membranes, but soon pierce the latter and run between the two planes of Intercostal muscles as far as the middle of the rib.

They then enter the substance of the Intercostales interni, and, running amidst their fibers as far as the costal cartilages, they gain the inner surfaces of the muscles and lie between them and the pleura.

Near the sternum, they cross in front of the internal mammary artery and Transversus thoracis muscle, pierce the Intercostales interni, the anterior intercostal membranes, and Pectoralis major, and supply the integument of the front of the thorax and over the

mamma, forming the anterior cutaneous branches of the thorax; the branch from the second nerve unites with the anterior supraclavicular nerves of the cervical plexus.

**Branches**

Numerous slender muscular filaments supply the Intercostales, the Subcostales, the Levatores costarum, the Serratus posterior superior, and the Transversus thoracis. At the front of the thorax some of these branches cross the costal cartilages from one intercostal space to another.

- **Lateral cutaneous branches** (rami cutanei laterales) are derived from the intercostal nerves, about midway between the vertebræ and sternum; they pierce the Intercostales externi and Serratus anterior, and divide into anterior and posterior branches.
- The **anterior branches** run forward to the side and the forepart of the chest, supplying the skin and the mamma; those of the fifth and sixth nerves supply the upper digitations of the Obliquus externus abdominis.
- The **posterior branches** run backward, and supply the skin over the scapula and Latissimus dorsi.

The lateral cutaneous branch of the second intercostal nerve does not divide, like the others, into an anterior and a posterior branch; it is named the **intercostobrachial nerve** (Fig. 816). It pierces the Intercostalis externus and the Serratus anterior, crosses the axilla to the medial side of the arm, and joins with a filament from the medial brachial cutaneous nerve. It then pierces the fascia, and supplies the skin of the upper half of the medial and posterior part of the arm, communicating with the posterior brachial cutaneous branch of the radial nerve. The size of the intercostobrachial nerve is in inverse proportion to that of the medial brachial cutaneous nerve. A second intercostobrachial nerve is frequently given off from the lateral cutaneous branch of the third intercostal; it supplies filaments to the axilla and medial side of the arm.

## The Lower Thoracic Nerves: 7th-11th

*See Thoraco-abdominal nerves*

## The Lower Thoracic Nerves: 12th

### Anterior division

*See subcostal nerve*

**ateral cutaneous branch**

The lateral cutaneous branch of the last thoracic nerve is large, and does not divide into an anterior and a posterior branch.

It perforates the Obliqui internus and externus, descends over the iliac crest in front of the lateral cutaneous branch of the iliohypogastric, and is distributed to the skin of the front part of the gluteal region, some of its filaments extending as low as the greater trochanter.

# Anatomy Tables - Thoracic Wall, Pleura, & Pericardium

## Topographical Anatomy of the Thorax

| Structure/Space | Description/Boundaries | Significance |
|---|---|---|
| mediastinum, anterior | between sternum and pericardial sac; extends from thoracic inlet to diaphragm | contains sternopericardial ligaments & lymph nodes (Latin, medius = middle + stare = stand, thus that area which stands in the middle of the thorax) |
| mediastinum, middle | bounded by pericaridal sac | contains heart, pericardial cavity, great vessels, and phrenic nerves (Latin, medius = middle + stare = stand, thus that area which stands in the middle of the thorax) |
| mediastinum, posterior | between pericaridal sac and vertebral bodies | contains esophagus, descending thoracic aorta, azygos system, thoracic duct, and lymph nodes (Latin, medius = middle + stare = stand, thus that area which stands in the middle of the thorax) |
| mediastinum, superior | bounded by thoracic inlet above and plane through sternal angle below | contains great vessels, trachea, esophagus, phrenic and vagus nerves (Latin, medius = middle + stare = stand, thus that area which stands in the middle of the thorax) |
| midaxillary line | an imaginary vertical line passing through | used as a surface landmark for |

| | | |
|---|---|---|
| | the middle of the axilla | descriptive purposes |
| midclavicular line | an imaginary vertical line passing through the midshaft of the clavicle | used as a surface landmark for descriptive purposes |
| nipple | located superficial to the 4th intercostal space in the male and prepuberal female | location of the left nipple may be used to help locate the apex of heart, which is approximately 8 cm from the midline in the left 5th intercostal space; a surface landmark used to place the stethoscope for auscultation of the bicuspid valve |
| sternal angle | a protrusion on the anterior thoracic wall at the junction of the manubrium and body of the sternum (manubriosternal symphysis) | sternal angle is the location of the attachment of t the costal cartilage of the 2nd rib to the sternum; an imaginary horizontal plane through the sternal angle passes through the T4/T5 intervertebral disc and marks the inferior boundary of the superior mediastinum |
| suprasternal notch | the notch located at the superior border of the manubrium of the sternum, between the sternal ends of the clavicles | also known as: jugular notch |
| thoracic inlet | the opening at the superior end of the rib cage through which cervical structures enter the thorax; bounded by the T1 vertebral body, both of the 1st ribs and their costal cartilages, and the manubrium | thoracic inlet marks the boundary between the neck and the superior mediastinum; also known as: superior thoracic aperture |

| | | |
|---|---|---|
| | of the sternum | |
| thoracic outlet | the opening at the inferior end of the rib cage through which thoracic structures exit the thorax; it is bounded by the T12 vertebral body, both 12th ribs, the costal cartilages of ribs 7-12, and the xiphisternal joint | thoracic outlet is closed by the respiratory diaphragm which is attached at its boundary; also known as: inferior thoracic aperture |
| costal margin | the inferior margin of the lowest costal cartilages and ribs | serves as part of the origin of the respiratory diaphragm |

**Osteology of the Thorax**

| Bone | Structure | Description | Notes |
|---|---|---|---|
| **rib** | | the bone forming the lateral thoracic wall | 12 pairs; several types are described: typical or "true" ribs, "false" ribs, "floating" ribs; all three types of ribs have many features in common: head, neck, tubercle, angle, body, costal groove |
| | head | posteromedial end of the rib | it articulates with demifacets of two adjacent vertebral bodies |
| | neck | the constricted region lateral to the head of the rib | the neck of the rib is located between the head and the tubercle |
| | tubercle | a projection located posteroinferior and | it articulates with the transverse process of a vertebra |

| | | | |
|---|---|---|---|
| | | lateral to the neck of the rib | |
| | body | the shaft of the rib | the body is the longest part of a typical rib |
| | angle | the marked angulation of the body located just lateral to the tubercle | the angle of the rib is its most posterior part |
| | costal groove | the groove on the inner surface of the inferior border of the body of the rib | it accommodates the intercostal neurovascular bundle; the costal groove provides a protective function for the intercostal neurovascular bundle, |
| **ribs 1-7** | | "true" ribs - those which attach directly to the sternum | true ribs actually attach to the sternum by means of a costal cartilage and a true synovial joint |
| **rib 1** | | the most cephalic rib | it is the broadest, shortest and widest of the ribs; the scalene tubercle marks its superior surface and is an elevation between grooves for the subclavian vein & artery; the scalene tubercle is the attachment site of the scalenus anterior m. |
| **rib 2** | | the rib attached to the 1st and 2nd thoracic vertebrae | it articulates via a costal cartilage with the sternum at the level of the sternal angle; its superior surface is roughened by the attachments of the scalene mm. |
| **rib 8-10** | | "false" ribs | they articulate via costal cartilages with the costal cartilage of rib 7 |
| **rib 11-** | | "floating" ribs | the anterior ends of these ribs do not articulate |

| | | | |
|---|---|---|---|
| 12 | | | with the sternum or the costal cartilage of the rib above; their costal cartilages are short and end in the muscle of the posterolateral abdominal wall |
| **sternum** | | the broad flat bone forming the anterior thoracic wall | it is formed by three parts: manubrium, body, xiphoid process |
| | manubrium | the superior part of the sternum | Latin, manubrium = handle, as in the handle of a sword |
| | jugular (suprasternal) notch | a notch on the superior border of the manubrium | it is located between the clavicular notches which articulate with the sternal ends of the clavicles (Latin, jugular = throat) |
| | clavicular notch | a notch on the superolateral border of the manubrium | it articulate with the sternal end of the clavicle |
| | sternal angle | the junction of the manubrium and body of the sternum | it is an anterior projection located at the level of the costal cartilage of rib 2; an important landmark for internal thoracic anatomy |
| | body | the middle part of the sternum | it articulates with the manubrium superiorly and the xiphoid process inferiorly; laterally it articulates with the costal cartilages of ribs 2-7 |
| | xiphoid process | the inferior part of the sternum | it is variable in size, shape & ossification; it articulates with the body of the sternum superiorly (Greek, xiphos = sword + eidos = appearance, the tip of the sternum is pointed like |

| | | | |
|---|---|---|---|
| | | | the tip of a sword) |

## Muscles of the Thoracic Wall

| Muscle | Origin | Insertion | Action | Innervation | Artery | Notes |
|---|---|---|---|---|---|---|
| external intercostal | lower border of a rib within an intercostal space | upper border of the rib below, coursing, downward and medially | keeps the intercostal space from blowing out or sucking in during respiration | intercostal nerves (T1-T11) | intercostal a. | 11 in number; they extend from the tubercle of the rib to the costochondral junction; continuous with the external intercostal membrane anteriorly (Latin, costa = rib) |
| internal intercostal | upper border of a rib | lower border of rib above, coursing up and medially | keeps the intercostal space from blowing out or sucking in during respiration | intercostal nerves (T1-T11) | intercostal a. | 11 in number; they extend from the margin of the sternum to the angle of the rib; continuous posteriorly with the internal intercostal membrane (Latin, costa = rib) |

| | | | | | | |
|---|---|---|---|---|---|---|
| innermost intercostal | upper borders of a rib | fibers course up and medially to insert on the inferior margin of the rib above | keeps the intercostal space from blowing out or sucking in during respiration | intercostal nerves (T1-T11) | intercostal a. | innermost intercostal mm. have the same fiber direction as the internal intercostal mm., the only difference being that they lie deep to the intercostal neurovascular bundle (Latin, costa = rib) |
| subcostalis | angle of ribs | angle of a rib 2-3 ribs above origin | compresses the intercostal spaces | intercostal nerves | intercostal a. | subcostalis, transversus thoracis & innermost intercostal mm. make up the deepest intercostal muscle layer (Latin, costa = rib) |
| transversus thoracis | posterior surface of the sternum | inner surfaces of costal cartilages 2-6 | compresses the thorax for forced expiration | intercostal nerves 2-6 | internal thoracic a. | transversus thoracis, subcostalis & innermost intercostal mm. make up the |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | innermost intercostal muscle layer |

| Joints and Ligaments of the Anterior Thorax | | |
|---|---|---|
| sternoclavicular joint | the joint what connects the clavicle with the sternum | a synovial joint; its joint capsule is subdivided by a fibrous articular disc; it is strengthened by the sternoclavicular, interclavicular and costoclavicular ligaments; the sternoclavicular joint has the range of movement, but not the form, of a ball and socket joint |
| sternoclavicular ligament | a ligament that reinforces the capsule of the sternoclavicular joint | the sternoclavicular ligament has two parts: anterior and posterior; it is a very strong ligament; the combined effect of this ligament, the costoclavicular ligament and the interclavicular ligament is to produce a very strong sternoclavicular joint that seldom dislocates |
| sternocostal joints | the articulations that connect the costal cartilages with the sternum | a synchondrosis (rib 1) or synovial joints (ribs 2-10); sternocostal synovial joints involving ribs 2-7 contain thin joint capsules; interchondral joints involving ribs 8-10 have simple gliding synovial articulations; radiate sternocostal ligaments reinforce the sternocostal articulations |
| xiphisternal joint | the articulation that connects the xiphoid | a synchondrosis; the cartilage within this joint usually becomes ossified in old age; the |

| | | |
|---|---|---|
| | process with the body of the sternum | xiphisternal joint marks the inferior extent of the thoracic cavity |

**Arteries**

| Artery | Source | Branches | Supply to | Notes |
|---|---|---|---|---|
| epigastric, superior | internal thoracic a. | no named branches | upper rectus abdominis m., upper abdominal wall | superior epigastric a. is the direct continuation of the internal thoracic a.; it anastomoses with the inferior epigastric a. within the rectus abdominis m. |
| intercostal, anterior | internal thoracic a. (upper 6 intercostal spaces), musculophrenic a. (7-10th intercostal spaces) | unnamed muscular branches | intercostal muscles anteriorly; skin overlying the intercostal muscles | there are two anterior intercostal aa. per side per intercostal space, one coursing above and one coursing below each rib |
| intercostal, posterior | highest intercostal (upper 2 intercostal | posterior br., spinal br., anterior br., collateral br., lateral cutaneous br. | intercostal muscles, spinal cord and vertebral | posterior intercostal aa. supply the lateral and posterior portions of the intercostal |

| | | | | |
|---|---|---|---|---|
| | spaces), descending thoracic aorta (3rd-11th intercostal spaces) | | column, deep back muscles, skin and superficial fascia overlying the intercostal spaces | space; anterior intercostal aa. supply the anterior portions of the intercostal spaces |
| internal thoracic | subclavian a. (1st part) | pericardiacophrenic a., perforating brs., anterior intercostal aa., mediastinal brs., thymic brs., musculophrenic a., superior epigastric a. | mediastinum, anterior thoracic wall, anterior abdominal wall, respiratory diaphragm | internal thoracic a. is also known as: internal mammary a. |
| musculophrenic | internal thoracic a. | anterior intercostal aa. | anterior diaphragm, anterior aspects of intercostal spaces 7-10 or 11 | musculophrenic a. supplies muscles that develop in the septum transversum (Greek, phreno = diaphragm) |
| pericardiacophrenic | internal thoracic a. | pericardial br., sternal br., mediastinal br. | pericardial sac, pleura, diaphragm | pericardiacophrenic a. accompanies the phrenic n. |
| aorta, ascending | left ventricle of | left & right coronary | heart, entire | (Greek, aorta = to lift) |

| | heart | aa., continues as aortic arch | body | |
|---|---|---|---|---|
| aortic arch | the continuation of the ascending aorta | brachiocephalic trunk, left common carotid a., left subclavian a. | the entire body except the heart | aortic arch continues as the descending thoracic aorta; the ligamentum arteriosum connects to the inferior surface of the aortic arch and marks the location of the fetal ductus arteriosus (Greek, aorta = to lift) |
| pulmonary trunk | right ventricle | right pulmonary a., left pulmonary aa. | lungs | the pulmonary trunk carries deoxygenated blood from the heart to the right and left pulmonary aa.; each pulmonary a. carries deoxygenated blood to the hilum of one lung; bronchial aa. supply oxygenated blood to the tissues of the lung as far distally in the bronchial tree as the respiratory bronchioles |

## Veins

| Vein | Tributaries | Drains Into | Region Drained | Notes |
|---|---|---|---|---|
| vena cava, inferior | union of paired common iliacs; lumbar vs. 4-1, rt. ovarian/testicular, renal vs., rt. suprarenal, rt. inferior phrenic, hepatic vs. | rt. atrium | body below diaphragm | |
| vena cava, superior | union of paired brachiocephalics; azygos arch | rt. atrium | body above diaphragm except for pulmonary vs. & heart | |
| intercostal, posterior | spinal trib., posterior trib., collateral trib., lateral cutaneous trib. | 1st: brachiocephalic; 2nd-4th: superior intercostal; right 5th-11th: azygos; left 5th-7th or 8th: accessory hemiazygos; left 9th-11th: hemiazygos | intercostal space & muscles & adjacent ribs, spinal cord segment & vertebra | |
| intercostal, superior | 2nd-4th posterior intercostal | right: arch of azygos; left: left brachiocephalic | intercostal spaces 2-4 | |
| pulmonary | | left atrium | lungs | usually two pulmonary vs. per side, sup. & inf., empty into left atrium |

## Lymphatics

| Structure | Location | Afferents from | Efferents to | Regions drained | Notes |
|---|---|---|---|---|---|
| parasternal nodes | lateral border of sternum, along the course of the internal thoracic vessels | anterior phrenic nodes, lymphatic vessels from the anterior thoracic wall | larger lymphatic vessels in the root of the neck | medial side of the mammary gland; medial part of the anterior chest wall and muscles | parasternal nodes constitute an important drainage pattern in cases of cancer of the mammary gland; one or two parasternal nodes may be found in the anterior end of intercostal spaces 1-6; also known as: sternal nodes |

## Nerves

| Nerve | Source | Branches | Motor | Sensory | Notes |
|---|---|---|---|---|---|
| intercostal n. | ventral primary rami of spinal nerves T1-T11 | lateral & anterior cutaneous brs. | intercostal muscles; abdominal wall muscles (via T7-T11); muscles of the forearm and hand (via T1) | skin of the chest and abdomen anterolaterally; skin of the medial side of the upper limb | intercostal n.travels below the posterior intercostal a. in the costal groove (Latin, |

| | | | | | |
|---|---|---|---|---|---|
| | | | | (via T1-T2) | costa = rib) |
| phrenic n. | ventral primary rami of spinal nerves C3-C5 (cervical plexus) | no named branches | skeletal muscle of the respiratory diaphragm | diaphragmatic pleura; some fibers contributed to the pericardium and to the adjacent mediastinal and costal pleurae | phrenic n. crosses the anterior surface of the anterior scalene m. (Greek, phren = diaphragm, from which we derive our word "frenzy," for the diaphragm was considered to be the seat of emotions) |
| subcostal n. | ventral primary ramus of T12 | lateral cutaneous br., anterior cutaneous br. | muscles of the abdominal wall | skin of the anterolateral abdominal wall | the subcostal n. is equivalent to a posterior intercostal n. found at higher thoracic levels (Latin, costa = rib) |

| | | | | | |
|---|---|---|---|---|---|
| vagus n. | medulla: dorsal motor nucleus (GVE preganglionic parasympathetic); inferior ganglion (GVA); nucleus ambiguus (SVE); superior ganglion (GSA); inferior ganglion(SVA) | auricular br., pharyngeal br., superior laryngeal, superior and inferior cervical cardiac brs., recurrent laryngeal n., thoracic cardiac brs., brs. to the pulmonary plexus, brs. to the esophageal plexus, anterior and posterior vagal trunks | SVE: intrinsic muscles of the larynx, pharynx (except stylopharyngeus), and palate (except tensor veli palatini); GVE: smooth muscle of the respiratory tree & gut (proximal to the left colic flexure), heart; secretomotor: mucous glands of the larynx, respiratory tree, pharynx and gut; secretomotor to digestive glands | GSA: skin of the external auditory meatus; GVA: viscera of head, neck, thorax & abdomen proximal to the left colic flexure; SVA: taste from the epiglottis | also known as: CN X, 10th cranial nerve; the vagus n. passes through the jugular foramen to exit the posterior cranial fossa; (Latin, vagus = wanderer so called because of its extensive distribution to the body cavities) |
| recurrent laryngeal n. | vagus n. (X) | esophageal brs., tracheal brs., cardiac brs., pharyngeal brs., inferior laryngeal n. | upper esophagus, lower pharynx, laryngeal mm. (except cricopharyngeus); smooth muscle of the trachea; | upper esophagus, lower pharynx, larynx below the vocal folds, GVA from heart | right recurrent laryngeal n. loops posteriorly around the right subclavian a.; |

| | | | | | |
|---|---|---|---|---|---|
| | | | secretomotor to mucosal glands in the upper esophagus, lower pharynx, larynx below the vocal fold, trachea; cardiac muscle of the heart (slows heart rate, decreases force of contraction) | | left recurrent laryngeal n. loops posteriorly around the aortic arch and ligamentum arteriosum; the inferior laryngeal br. supplies all intrinsic muscles of the larynx EXCEPT the cricothyroid m. |

| Viscera/Fascia of the Chest | | |
|---|---|---|
| **Organ/Part of Organ** | **Location/Description** | **Notes** |
| pleura | serous membrane lining the pleural cavity | there are two types of pleura: visceral pleura covers the lungs, parietal pleura lines the inner surfaces of the walls of pleural cavity; parietal pleura is sensitive to pain but visceral pleura is |

| | | |
|---|---|---|
| | | not sensitive to pain (Greek, pleura = rib, side) |
| cupula | serous membrane lining the pleural cavity which extends above the level of the 1st rib into the root of the neck | cupular pleura is continuous inferiorly with the costal and mediastinal parietal pleurae; it is reinforced by a specialization of scalene fascia (called Sibson's fascia or suprapleural membrane); also known as: cervical parietal pleura or cervical dome of pleura |
| pleura, cervical parietal | serous membrane lining the pleural cavity which extends above the level of the 1st rib into the root of the neck | cervical parietal pleura is continuous inferiorly with the costal and mediastinal parietal pleurae; it is reinforced by a specialization of scalene fascia (called Sibson's fascia or suprapleural membrane); also known as: cupula or cervical dome of pleura (Latin, paries = wall (of a cavity)) |
| pleura, costal parietal | serous membrane lining the pleural cavity on the inner surfaces of the ribs, costal cartilages, and intercostal mm. | costal parietal pleura is continuous anteriorly with the mediastinal parietal pleura at the costomediastinal reflection; it is continuous posteriorly with the mediastinal parietal pleural at the vertebral bodies; it is continuous inferiorly with the diaphragmatic parietal pleura at the costodiaphragmatic reflection; it is continuous superiorly with the cervical parietal pleura at the level of the 1st rib (Latin, paries = wall (of a cavity)) |
| pleura, diaphragmatic parietal | serous membrane lining the pleural cavity on the superior surface of the diaphragm | diaphragmatic parietal pleura is continuous superiorly with the costal parietal pleura at the costodiaphragmatic reflection; it is continuous superiorly with the mediastinal pleura at the |

| | | |
|---|---|---|
| | | inferomedial borders of the pleural cavities (Latin, paries = wall (of a cavity)) |
| pleura, mediastinal parietal | serous membrane lining the pleural cavity on the lateral surface of the mediastinum | mediastinal parietal pleura is continuous anteriorly with the costal parietal pleura at the costomediastinal reflection; it is continuous inferiorly with the diaphragmatic pleura at the inferomedial borders of the pleural cavities; it is continuous posteriorly with the costal parietal pleura lateral to the vertebral bodies; it is continuous superiorly with the cervical pleura at the level of the 1st rib (Latin, paries = wall (of a cavity)) |
| pleura, visceral | serous membrane lining the surfaces of the lungs | visceral pleura extends into the oblique and horizontal fissures of the lungs; it does not have pain fibers (Latin, viscus = internal organ) |
| pulmonary ligament | fold of pleura located below the root of the lung | pulmonary ligament is where the visceral pleura and the mediastinal parietal pleura are continuous with each other |
| costodiaphragmatic recess | a potential space between the apposing surfaces of the costal and diaphragmatic parietal pleura | this space extends to the 8th rib in the midclavicular line, 10th rib in the midaxillary line, and 12th rib at the medial scapular/paravertebral line. |
| costomediastinal recess | a potential space between the apposing surfaces of the costal and mediastinal parietal pleura | this space is more pronounced on the left because of the location of the heart |

| | | |
|---|---|---|
| endothoracic fascia | connective tissue between inner aspect of chest wall & costal parietal pleura | equivalent to transversalis fascia layer of the abdomen |
| pericardial sinus, oblique | an area of the pericardial cavity located behind the left atrium of heart | serous pericardium reflects onto the inferior vena cava and pulmonary vv. to define this space |
| pericardial sinus, transverse | an area of the pericardial cavity located behind the aorta and pulmonary trunk and anterior to the superior vena cava | transverse pericardial sinus was a simple structure when the heart tube began to form during development; it separates the outflow vessels from the inflow vessels of the heart |
| pericardium, fibrous | a fibrous sac that attaches to the central tendon of the diaphragm and fuses with the adventitia of the great vessels superiorly | fibrous pericardium contains the pericardial cavity and heart; it is lined on its inner surface by the parietal layer of serous pericardium; it defines the outermost boundary of the middle mediastinum |
| pericardium, parietal serous | serous membrane lining the pericardial cavity; it is located on the inner surface of the fibrous pericardium | parietal serous pericardium reflects onto the heart at the origins of the great vessels to become continuous with the visceral serous pericardium |
| pericardium, visceral serous | serous membrane covering the surface of the heart | visceral serous pericardium reflects onto the inner surface of the fibrous pericardium at the origins of the great vessels to become continuous with the parietal serous pericardium; also known as: epicardium |
| hilum of lung | medial surface of the lung | the point at which the structures forming the root |

| | | |
|---|---|---|
| | | - the main bronchus, pulmonary vessels, bronchial vessels, lymphatic vessels, and nerves - enter and leave the lung |
| coronary sulcus | groove separating atria from ventricles | coronary sinus, circumflex a., & right coronary a. lie in coronary sulcus, (Latin, coronary = something that is "crown-like", i.e., goes around in a loop) |
| apex | tip of left ventricle | located 3" left of midline at level of 5th intercostal space |
| base | superior aspect of heart | where aorta, pulmonary trunk & superior vena cava enter the heart |
| atrium, right | forms the right margin of the heart | receives blood from the superior vena cava, inferior vena cava & coronary sinus |
| atrium, left | located on the posterior aspect of the heart | receives blood from the pulmonary vv. |
| auricle | projects anteriorly from the atrium | one on each atrium, they lie beside aorta & pulmonary trunk (Latin, auricula = little ear, the auricle of the atrium is shaped like a little ear) |
| interventricular sulcus, anterior | groove between ventricles on anterior surface of heart | anterior interventricular a. & great cardiac v. lie within sulcus (Latin/Greek, holkos (sulcus)= furrow) |
| interventricular sulcus, posterior | groove between ventricles on diaphragmatic surface of heart | posterior interventricular a. & middle cardiac v. lie within sulcus (Latin/Greek, holkos (sulcus)= furrow) |
| | | |

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|---|---|---|
| ligamentum arteriosum | remnant of ductus arteriosus; connects left pulmonary a. near origin with undersurface of aortic arch | left recurrent laryngeal n. passes beneath it |
| right (acute) margin | inferior margin formed by right ventricle | called acute due to the sharp angle formed between the anterior and diaphragmatic surfaces of the right ventricle |
| left (obtuse) margin | left, upper margin formed by left ventricle | called obtuse due to the broad curving angle formed by the anterior and diaphragmatic surfaces of the left ventricle |
| trachea | main airway that lies anterior to the esophagus | trachea extends from vertebral level C6 to the level of the T4/5 intervertebral disc; superiorly it is connected to the cricoid cartilage via the cricotracheal ligament; it bifurcates into two primary bronchi (Greek, trachys = rough) |

## Clinical Terms

| Term | Definition |
|---|---|
| collateral circulation | compensatory circulation carried on through secondary channels after obstruction of the principal vessel supplying the part; collateral circulation is common around moveable joints |
| shingles (herpes zoster) | disease in adults caused by Varicella zoster virus (Herpetoviridae), that in children causes chicken pox; arises by reactivation (usually associated with a decline in cell-mediated immunity) of latent virus that persists in spinal or cranial sensory nerve ganglia |

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| thoracotomy | a surgical procedure in which an incision is made opening the chest cavity |
| sternotomy | midline incision through the sternum |
| funnel chest | a developmental anomaly in which the lower sternum is posteriorly dislocated and concavely deformed, resulting in a funnel-shaped thorax; also known as pectus excavatum |
| pigeon chest | prominence of the breast bone (sternum); also known as pectus carinatum |
| empyema | the accumulation of pus in a cavity of the body, when used without a descriptive qualifier; it refers to thoracic empyema (Greek, empyema = suppuration) |
| thoracocentesis | a medical procedure that involves the removal of fluid from the chest cavity using a hollow-bore needle; performed for therapeutic reasons when drawing off large volumes of fluid and for diagnostic reasons (to analyze the fluid) (Greek, -centesis = puncture) |
| pneumothorax | a collapse of the lung due to an abrupt change in the intrapleural pressure within the chest cavity; may be due to lung or chest penetration (trauma); may also occur spontaneously (rupture of the lung - typically in tall, young males); symptoms include shortness of breath and severe, one-sided (affected side) chest pain on inhalation; signs include decreased breath sounds and hyperresonance on the affected side. A tension pneumothorax is one which allows air to enter the pleural space (from a hole in the chest wall or the lung) but not escape leading to a valve effect pushing the mediastinal structures to the opposite side - the additional signs and symptoms signaling this medical emergency are shock from decreased venous return to the heart (IVC is kinked due to mediastinum being pushed to one side) and tracheal deviation away from the affected side. |
| pleurisy | inflammation of the pleura with exudation into its cavity and upon its surface; may occur as either an acute or a chronic process; in acute pleurisy the pleura becomes |

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| | reddened, then covered with an exudate of lymph, fibrin, and cellular elements (the dry stage); the disease may progress to the second stage, in which a copious exudation of serum occurs (stage of liquid effusion); the inflamed surface of the pleura tends to become connected by adhesions, which are usually permanent; symptoms are a stitch in the side, a chill, followed by fever and a dry cough; as effusion occurs there is an onset of dyspnea and a diminution of pain; the patient lies on the affected side (Greek, pleura = a rib or the side) |
| crepitus | a crackling sound in the lungs or a grating feeling (Latin, crepo = to rattle) |
| tension pneumothorax | a condition in which the ruptured tissue forms a valve that permits air to enter the chest cavity upon inspiration, but does not allow air to escape during expiration and therefore greatly increases the pressure inside the cavity such that the vessels and trachea are displaced to the opposite side (Greek, pneuma = air + thorax = chest) |
| tachypnea | abnormally rapid respiration rate; normal resting adult respiration rate is 12-20 breaths per minute (Greek, tachy = quick + pnea/pnoie = breathing) |
| dyspnea | difficulty or distress in breathing (Greek, pnea/pnoie = breathing) |
| parasthesia | an abnormal spontaneous sensation such as burning, pricking, and numbness |
| pleural effusion | excess fluid in the pleural space. This can be either a transudate or an exudate (Greek, pleura = a rib or the side) |
| hemothorax | blood in the pleural space |

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# Thoracic Wall, Intercostal Space, Pleural Cavities, Lungs

## Anatomy Tables for Today's Topic



| Topographic Anatomy of the Thorax | | |
|---|---|---|
| **Structure/Space** | **Description/Boundaries** | **Significance** |
| midaxillary line | an imaginary vertical line passing through the middle of the axilla | used as a surface landmark for descriptive purposes |
| midclavicular | an imaginary vertical line passing through the midshaft of | used as a surface landmark for descriptive purposes |

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| line | the clavicle | |
| nipple | located superficial to the 4th intercostal space in the male and prepuberal female | location of the left nipple may be used to help locate the apex of heart, which is approximately 8 cm from the midline in the left 5th intercostal space; a surface landmark used to place the stethoscope for auscultation of the bicuspid valve |
| sternal angle | a protrusion on the anterior thoracic wall at the junction of the manubrium and body of the sternum (manubriosternal symphysis) | sternal angle is the location of the attachment of t the costal cartilage of the 2nd rib to the sternum; an imaginary horizontal plane through the sternal angle passes through the T4/T5 intervertebral disc and marks the inferior boundary of the superior mediastinum |
| suprasternal notch | the notch located at the superior border of the manubrium of the sternum, between the sternal ends of the clavicles | also known as: jugular notch |
| thoracic inlet | the opening at the superior end of the rib cage through which cervical structures enter the thorax; bounded by the T1 vertebral body, both of the 1st ribs and their costal cartilages, and the manubrium of the sternum | thoracic inlet marks the boundary between the neck and the superior mediastinum; also known as: superior thoracic aperture |
| thoracic outlet | the opening at the inferior end of the rib cage through which thoracic structures exit the thorax; it is bounded by the T12 vertebral body, both 12th ribs, the costal cartilages of ribs 7-12, and the xiphisternal joint | thoracic outlet is closed by the respiratory diaphragm which is attached at its boundary; also known as: inferior thoracic aperture |

**Bones of the Thoracic Wall**

| Bone | Structure | Description | Notes |
|---|---|---|---|
| rib | | the bone forming the lateral thoracic wall | 12 pairs; several types are described: typical or "true" ribs, "false" ribs, "floating" ribs; all three types of ribs have many features in common: head, neck, tubercle, angle, body, costal groove |
| | head | posteromedial end of the rib | it articulates with demifacets of two adjacent vertebral bodies |
| | neck | the constricted region lateral to | the neck of the rib is located between the head and the tubercle |

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|---|---|---|---|
| | | the head of the rib | |
| | tubercle | a projection located posteroinferior and lateral to the neck of the rib | it articulates with the transverse process of a vertebra |
| | body | the shaft of the rib | the body is the longest part of a typical rib |
| | angle | the marked angulation of the body located just lateral to the tubercle | the angle of the rib is its most posterior part |
| | costal groove | the groove on the inner surface of the inferior border of the body of the rib | it accommodates the intercostal neurovascular bundle; the costal groove provides a protective function for the intercostal neurovascular bundle, |
| ribs 1-7 | | "true" ribs - those which attach directly to the sternum | true ribs actually attach to the sternum by means of a costal cartilage and a true synovial joint |
| rib 1 | | the most cephalic rib | it is the broadest, shortest and widest of the ribs; the scalene tubercle marks its superior surface and is an elevation between grooves for the subclavian vein & artery; the scalene tubercle is the attachment site of the scalenus anterior m. |
| rib 2 | | the rib attached to the 1st and 2nd thoracic vertebrae | it articulates via a costal cartilage with the sternum at the level of the sternal angle; its superior surface is roughened by the attachments of the scalene mm. |
| rib 8-10 | | "false" ribs | they articulate via costal cartilages with the costal cartilage of rib 7 |
| rib 11-12 | | "floating" ribs | the anterior ends of these ribs do not articulate with the sternum or the costal cartilage of the rib above; their costal cartilages are short and end in the muscle of the posterolateral abdominal wall |
| sternum | | the broad flat bone forming the anterior thoracic wall | it is formed by three parts: manubrium, body, xiphoid process |
| | manubrium | the superior part of the sternum | manubrium means "handle", as in the handle of a sword |
| | jugular | a notch on the superior border | it is located between the clavicular notches which articulate with the sternal |

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|---|---|---|---|
| | (suprasternal) notch | of the manubrium | ends of the clavicles |
| | clavicular notch | a notch on the superolateral border of the manubrium | it articulate with the sternal end of the clavicle |
| | sternal angle | the junction of the manubrium and body of the sternum | it is an anterior projection located at the level of the costal cartilage of rib 2; an important landmark for internal thoracic anatomy |
| | body | the middle part of the sternum | it articulates with the manubrium superiorly and the xiphoid process inferiorly; laterally it articulates with the costal cartilages of ribs 2-7 |
| | xiphoid process | the inferior part of the sternum | xiphoid means "sword shaped"; it is variable in size, shape & ossification; it articulates with the body of the sternum superiorly |

**Muscles of the Thoracic Wall**

| Muscle | Origin | Insertion | Action | Innervation | Artery | Notes |
|---|---|---|---|---|---|---|
| external intercostal | lower border of a rib within an intercostal space | upper border of the rib below, coursing, downward and medially | keeps the intercostal space from blowing out or sucking in during respiration | intercostal nerves (T1-T11) | intercostal a. | 11 in number; they extend from the tubercle of the rib to the costochondral junction; continuous with the external intercostal membrane anteriorly |
| innermost intercostal | upper borders of a rib | fibers course up and medially to insert on the inferior margin of the rib above | keeps the intercostal space from blowing out or sucking in during respiration | intercostal nerves (T1-T11) | intercostal a. | innermost intercostal mm. have the same fiber direction as the internal intercostal mm., the only difference being that they lie deep to the intercostal neurovascular bundle |
| internal intercostal | upper border of a rib | lower border of rib above, coursing up and medially | keeps the intercostal space from blowing out or sucking in | intercostal nerves (T1-T11) | intercostal a. | 11 in number; they extend from the margin of the sternum to the angle of the rib; continuous posteriorly |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | during respiration | | | with the internal intercostal membrane |
| serratus posterior inferior | thoracolumbar fascia, spines of vertebrae T11-T12 and L1-L2 | ribs 9-12, lateral to the angles | pulls down lower ribs | branches of the ventral primary rami of spinal nerves T9-T12 | lowest posterior intercostal a., subcostal a., first two lumbar aa. | a respiratory muscle, it receives ventral ramus innervation; embryonically related to the intercostal muscles, not the deep back mm. |
| serratus posterior superior | ligamentum nuchae, spines of vertebrae C7 and T1-T3 | ribs 1-4, lateral to the angles | elevates the upper ribs | branches of the ventral primary rami of spinal nerves T1-T4 | posterior intercostal aa. 1-4 | a respiratory muscle, it receives ventral ramus innervation; embryonically related to the intercostal muscles, not the deep back mm. |
| subcostalis | angle of ribs | angle of a rib 2-3 ribs above origin | compresses the intercostal spaces | intercostal nerves | intercostal a. | subcostalis, transversus thoracis & innermost intercostal mm. make up the deepest intercostal muscle layer |
| transversus thoracis | posterior surface of the sternum | inner surfaces of costal cartilages 2-6 | compresses the thorax for forced expiration | intercostal nerves 2-6 | internal thoracic a. | transversus thoracis, subcostalis & innermost intercostal mm. make up the innermost intercostal muscle layer |

**Nerves of the Thoracic Wall**

| Nerve | Source | Branches | Motor | Sensory | Notes |
|---|---|---|---|---|---|
| intercostal n. | ventral primary rami of spinal nerves T1-T11 | lateral & anterior cutaneous brs. | intercostal muscles; abdominal wall muscles (via T7-T11); muscles of the forearm and hand (via T1) | skin of the chest and abdomen anterolaterally; skin of the medial side of the upper limb (via T1-T2) | intercostal n.travels below the posterior intercostal a. in the costal groove |

| | | | | | |
|---|---|---|---|---|---|
| subcostal n. | ventral primary ramus of T12 | lateral cutaneous br., anterior cutaneous br. | muscles of the abdominal wall | skin of the anterolateral abdominal wall | the subcostal n. is equivalent to a posterior intercostal n. found at higher thoracic levels |

**Arteries of the Thoracic Wall**

| Artery | Source | Branches | Supply | Notes |
|---|---|---|---|---|
| epigastric, superior | internal thoracic a. | no named branches | upper rectus abdominis m., upper abdominal wall | superior epigastric a. is the direct continuation of the internal thoracic a.; it s anastomoses with the inferior epigastric a. within the rectus abdominis m. |
| intercostal, anterior | internal thoracic a. (upper 6 intercostal spaces), musculophrenic a. (7-10th intercostal spaces) | unnamed muscular branches | intercostal muscles anteriorly; skin overlying the intercostal muscles | there are two anterior intercostal aa. per side per intercostal space, one coursing above and one coursing below each rib |
| intercostal, highest | costocervical trunk | posterior intercostal aa. for intercostal spaces 1-2 | intercostal muscles of intercostal spaces 1 and 2, vertebral column, deep back muscles | highest intercostal a. is also known as: supreme intercostal a. |
| intercostal, posterior | highest intercostal (upper 2 intercostal spaces), descending thoracic aorta (3rd-11th intercostal spaces) | posterior br., spinal br., anterior br., collateral br., lateral cutaneous br. | intercostal muscles, spinal cord and vertebral column, deep back muscles, skin and superficial fascia overlying the intercostal spaces | posterior intercostal aa. supply the lateral and posterior portions of the intercostal space; anterior intercostal aa. supply the anterior portions of the intercostal spaces |
| musculophrenic | internal thoracic a. | anterior intercostal aa. | anterior diaphragm, anterior aspects of | musculophrenic a. supplies muscles that develop in the |

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|---|---|---|---|---|
| | | | intercostal spaces 7-10 or 11 | septum transversum |
| thoracic, internal | subclavian a. (1st part) | pericardiocophrenic a., perforating brs., anterior intercostal aa., mediastinal brs., thymic brs., musculophrenic a., superior epigastric a. | mediastinum, anterior thoracic wall, anterior abdominal wall, respiratory diaphragm | internal thoracic a. is also known as: internal mammary a. |

**Veins of the Thoracic Wall**

| Vein | Tributaries | Drains Into | Regions Drained | Notes |
|---|---|---|---|---|
| intercostal, posterior | lateral cutaneous br. | 1st: brachiocephalic v.; 2nd-4th: superior intercostal v.; right 5th-11th: azygos v.; left 5th-7th or 8th: accessory hemiazygos v.; left 9th-11th: hemiazygos v. | intercostal space including skin, muscles and adjacent ribs; the spinal cord at that segmental level and the corresponding vertebra | the difference in termination of the intercostal vv. of the left and right sides is explained by the embryonic origin of the azygos system from the (originally symmetrical) supracardinal vv. |
| intercostal, superior | 2nd-4th posterior intercostal vv. | right: arch of the azygos v.; left: left brachiocephalic v, | intercostal spaces 2-4 | superior intercostal v. develops from the cephalic end of the supracardinal v. in the embryo |

**Fasciae of the Thorax**

| Structure | Location/Description | Notes |
|---|---|---|
| fascia, endothoracic | connective tissue lining the inner aspect of the chest wall | endothoracic fascia is located between the parietal pleura and the muscles and bones of the thoracic wall; it is equivalent to the transversalis fascia layer of the abdomen |
| fascia, Sibson's | part of the scalene fascia that lines the cervical parietal pleura | Sibson's fascia anchors the dome of cervical pleura; it is continuous with the endothoracic fascia at the level of the first rib |

**Joints of the Thoracic Wall**

| Joint or ligament | Description | Notes |
|---|---|---|
| costal cartilage | the cartilage that caps the medial end of the rib | costal cartilages of ribs 1-7 connect to the sternum; costal cartilages of ribs 8-10 connect to the costal cartilage of rib 7; costal cartilages of ribs 11 & 12 do not articulate anteriorly but end in the muscles of the abdominal wall |
| radiate sternocostal ligaments | ligaments that reinforce the sternocostal joint capsule | these ligaments connect the costal cartilages of ribs 1-7 with the sternum on both the anterior and posterior surfaces of the sternocostal articulation |
| sternal angle | the angle formed by the articulation between the manubrium and the body of the sternum | a synchondrosis; the cartilage within this joint usually does not become ossified until old age; the angle formed by this articulation is also called the angle of Louis; the sternal angle marks the level of the second costal cartilage from which all other ribs are counted |
| sternocostal joints | the articulations that connect the costal cartilages with the sternum | a synchondrosis (rib 1) or synovial joints (ribs 2-10); sternocostal synovial joints involving ribs 2-7 contain thin joint capsules; interchondral joints involving ribs 8-10 have simple gliding synovial articulations; radiate sternocostal ligaments reinforce the sternocostal articulations |
| xiphisternal joint | the articulation that connects the xiphoid process with the body of the sternum | a synchondrosis; the cartilage within this joint usually becomes ossified in old age; the xiphisternal joint marks the inferior extent of the thoracic cavity |

**Pleurae, Lungs and Bronchial Tree**

| Organ | Location/Description | Notes |
|---|---|---|
| pleura | serous membrane lining the pleural cavity | there are two types of pleura: visceral pleura covers the lungs, parietal pleura lines the inner surfaces of the walls of pleural cavity; parietal pleura is sensitive to pain but visceral pleura is not sensitive to pain |
| pleura, cervical parietal | serous membrane lining the pleural cavity which extends above the level of the 1st rib into the root of | cervical parietal pleura is continuous inferiorly with the costal and mediastinal parietal pleurae; it is reinforced by a specialization of scalene fascia (called Sibson's fascia or suprapleural membrane); also known as: cupula or cervical dome of pleura |

| | | |
|---|---|---|
| | the neck | |
| pleura, costal parietal | serous membrane lining the pleural cavity on the inner surfaces of the ribs, costal cartilages, and intercostal mm. | costal parietal pleura is continuous anteriorly with the mediastinal parietal pleura at the costomediastinal reflection; it is continuous posteriorly with the mediastinal parietal pleural at the vertebral bodies; it is continuous inferiorly with the diaphragmatic parietal pleura at the costodiaphragmatic reflection; it is continuous superiorly with the cervical parietal pleura at the level of the 1st rib |
| pleura, diaphragmatic parietal | serous membrane lining the pleural cavity on the superior surface of the diaphragm | diaphragmatic parietal pleura is continuous superiorly with the costal parietal pleura at the costodiaphragmatic reflection; it is continuous superiorly with the mediastinal pleura at the inferomedial borders of the pleural cavities |
| pleura, mediastinal parietal | serous membrane lining the pleural cavity on the lateral surface of the mediastinum | mediastinal parietal pleura is continuous anteriorly with the costal parietal pleura at the costomediastinal reflection; it is continuous inferiorly with the diaphragmatic pleura at the inferomedial borders of the pleural cavities; it is continuous posteriorly with the costal parietal pleura lateral to the vertebral bodies; it is continuous superiorly with the cervical pleura at the level of the 1st rib |
| pleura, visceral | serous membrane lining the surfaces of the lungs | visceral pleura extends into the oblique and horizontal fissures of the lungs; it does not have pain fibers |
| pulmonary ligament | fold of pleura located below the root of the lung | pulmonary ligament is where the visceral pleura and the mediastinal parietal pleura are continuous with each other |
| cupula | serous membrane lining the pleural cavity which extends above the level of the 1st rib into the root of the neck | cupular pleura is continuous inferiorly with the costal and mediastinal parietal pleurae; it is reinforced by a specialization of scalene fascia (called Sibson's fascia or suprapleural membrane); also known as: cervical parietal pleura or cervical dome of pleura |
| bronchi | the air conducting passages of the lungs | bronchi may be classified as primary, secondary (lobar), and tertiary (segmental) |
| bronchus, primary | first branch of the air conducting system arising from the bifurcation of the trachea at T4/T5 intervertebral disc | paired, right and left; one primary bronchus enters the hilus of each lung; the right primary bronchus is shorter, larger in diameter and more vertically oriented than the left so that aspirated foreign bodies tend to lodge in the right primary bronchus |
| bronchus, secondary | a branch of the air conducting system arising from the primary | there are 3 secondary bronchi in the right lung: upper, middle, lower; there are 2 secondary bronchi in the left lung: upper, lower; also known as: lobar bronchi |

| | | |
|---|---|---|
| | bronchus | |
| bronchus, tertiary | a branch of the air conducting system arising from the secondary (lobar) bronchus | there are 10 tertiary bronchi in the right lung: branching from the right superior lobar bronchus - apical, anterior, posterior; branching from the right middle lobar bronchus - medial, lateral; branching from the right inferior lobar bronchus - superior, anterior basal, posterior basal, medial basal, lateral basal; there are 8 tertiary bronchi in the left lung: branching from the left superior lobar bronchus - apicoposterior, anterior; branching from the lingular bronchus (off of the superior lobar bronchus) - superior lingular, inferior lingular; branching from the inferior lobar bronchus - superior, anteromedial basal, posterior basal, lateral basal; also known as: segmental bronchi |
| bronchus, segmental | a branch of the air conducting system arising from the secondary (lobar) bronchus | there are 10 tertiary bronchi in the right lung: branching from the right superior lobar bronchus - apical, anterior, posterior; branching from the right middle lobar bronchus - medial, lateral; branching from the right inferior lobar bronchus - superior, anterior basal, posterior basal, medial basal, lateral basal; there are 8 tertiary bronchi in the left lung: branching from the left superior lobar bronchus - apicoposterior, anterior; branching from the lingular bronchus (off of the superior lobar bronchus) - superior lingular, inferior lingular; branching from the inferior lobar bronchus - superior, anteromedial basal, posterior basal, lateral basal; also known as: tertiary bronchi |
| carina | keel-shaped cartilage lying within the tracheal bifurcation | carina trachealis is an important landmark during endoscopy of the bronchial tree |
| lung | the portion of the respiratory system where exchange of gasses occurs between the air and the blood; located in the thoracic cavity | paired; right lung is divided into three lobes: superior, middle and inferior; left lung has two lobes: superior and inferior |
| fissure, oblique | deep groove in the surface of the lung that separates the upper lobe from the lower lobe (both lungs), and the middle lobe from the lower lobe (right lung) | oblique fissure extends from the level of the T3 vertebra posteriorly to the 6th costochondral junction anteriorly |
| fissure, | deep groove in the surface of the | horizontal fissure extends from the 5th rib at the mid-axillary line along the 4th rib |

| | | |
|---|---|---|
| horizontal | lung that separates the middle lobe from the upper lobe (right lung only) | to the sternum anteriorly |
| lobe, inferior | the portion of the lung supplied by the inferior lobar bronchus | inferior lobe of the right lung: possesses 5 bronchopulmonary segments - superior, anterior basal, posterior basal, medial basal, lateral basal; inferior lobe of the left lung: possesses 4 bronchopulmonary segments - superior, anteromedial basal, posterior basal, lateral basal |
| lobe, middle | the portion of the right lung supplied by the middle lobar bronchus | middle lobe is found in the right lung only; it possesses 2 bronchopulmonary segments: medial and lateral; lingula of the inferior lobe of the left lung is equivalent to the middle lobe of the right lung |
| lobe, superior | the portion of the lung supplied by the superior lobar bronchus | superior lobe of the right lung: possesses three bronchopulmonary segments - apical, anterior and posterior; superior lobe of the left lung: possesses four bronchopulmonary segments - apicoposterior, anterior, superior lingular, inferior lingular |

**Nerves of the Thoracic Cavity**

| Nerve | Source | Branches | Motor | Sensory | Notes |
|---|---|---|---|---|---|
| phrenic n. | ventral primary rami of spinal nerves C3-C5 (cervical plexus) | no named branches | skeletal muscle of the respiratory diaphragm | diaphragmatic pleura; some fibers contributed to the pericardium and to the adjacent mediastinal and costal pleurae | phrenic n. crosses the anterior surface of the anterior scalene m. |
| plexus, pulmonary | continuous with the cardiac plexus; thoracic visceral nn.; pulmonary brs. of vagus | no named branches | parasympathetic: smooth muscle & glands of the bronchial tree; sympathetic: vascular smooth muscle of the lungs | none | pulmonary plexus is located along the pulmonary vessels and primary bronchi in the root of the lung |
| vagus n. | medulla: dorsal motor | auricular br., | SVE: intrinsic muscles of the | GSA: skin of the | also known as: CN |

| | | | | | |
|---|---|---|---|---|---|
| | nucleus (GVE preganglionic parasympathetic); inferior ganglion (GVA); nucleus ambiguus (SVE); superior ganglion (GSA); inferior ganglion (SVA) | pharyngeal br., superior laryngeal, superior and inferior cervical cardiac brs., recurrent laryngeal n., thoracic cardiac brs., brs. to the pulmonary plexus, brs. to the esophageal plexus, anterior and posterior vagal trunks | larynx, pharynx (except stylopharyngeus), and palate (except tensor veli palatini); GVE: smooth muscle of the respiratory tree & gut (proximal to the left colic flexure), heart; secretomotor: mucous glands of the larynx, respiratory tree, pharynx and gut; secretomotor to digestive glands | external auditory meatus; GVA: viscera of head, neck, thorax & abdomen proximal to the left colic flexure; SVA: taste from the epiglottis | X, 10th cranial nerve; the vagus n. passes through the jugular foramen to exit the posterior cranial fossa; vagus means "wanderer" in reference to its extensive distribution to the body cavities |

**Arteries of the Thoracic Cavity**

| Artery | Source | Branches | Supply | Notes |
|---|---|---|---|---|
| bronchial, left | descending thoracic aorta | right bronchial a. (occasionally) | lower trachea, bronchial tree | there are usually two left bronchial aa. |
| bronchial, right | 3rd right posterior intercostal | no named branches | lower trachea, bronchial tree | right bronchial a. may arise from the left bronchial a. |
| pulmonary a. | pulmonary trunk | right: superior lobar a. to the superior lobe and inferior lobar a. to the middle and inferior lobes; left: superior lobar a. to the superior lobe, inferior lobar a. to the inferior lobe | lungs | each pulmonary a. carries deoxygenated blood to the hilum of one lung |
| pulmonary trunk | right ventricle | right pulmonary a., left pulmonary a. | lungs | the pulmonary trunk carries deoxygenated blood from the heart to the right and left pulmonary aa.; each pulmonary a. carries deoxygenated blood to the hilum |

| | | | | |
|---|---|---|---|---|
| | | | | of one lung; bronchial aa. supply oxygenated blood to the tissues of the lung as far distally in the bronchial tree as the respiratory bronchioles |

**Veins of the Thoracic Cavity**

| Vein | Tributaries | Drains Into | Region Drained | Notes |
|---|---|---|---|---|
| pulmonary | lobar vv. | left atrium | lungs | usually two pulmonary vv. per side, superior & inferior; all empty into the left atrium |

**Lymphatics of the Lung and Bronchial Tree**

| Structure | Location | Afferents from | Efferents to | Regions drained | Notes |
|---|---|---|---|---|---|
| bronchomediastinal trunk | along the course of the brachiocephalic v. | union of efferents from the paratracheal nodes, parasternal nodes and anterior mediastinal nodes | left: thoracic duct; right: right lymphatic duct | thoracic wall and viscera; medial part of the mammary gland | right bronchomediastinal trunk receives lymph from the lower lobe of the left lung; bronchomediastinal trunk may drain directly into the venous system on either side |
| bronchopulmonary nodes | hilum of the lung | pulmonary nodes | tracheobronchial nodes | lung | bronchopulmonary nodes are also known as: hilar nodes |
| hilar nodes | at hilum of lung | pulmonary nodes | tracheobronchial nodes | lung | also known as: bronchopulmonary nodes |
| mediastinal nodes, anterior | along the course of the brachiocephalic vessels and aorta | lymphatic vessels from the anterior mediastinum and middle mediastinum | bronchomediastinal trunk | thymus, anterior respiratory diaphragm, pericardium, part of the heart | anterior mediastinal nodes are from 2 to 5 in number |
| | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| mediastinal nodes, posterior | along azygos system of veins and esophagus | viscera of the posterior mediastinum and chest wall | thoracic duct, inferior tracheobronchial nodes, superior tracheobronchial nodes | posterior mediastinum, posterior aspect of the heart and pericardium, posterior part of the respiratory diaphragm | posterior mediastinal nodes drain primarily to the thoracic duct |
| paratracheal nodes | coursing along the lateral surface of the trachea and esophagus | superior tracheobronchial nodes | bronchomediastinal trunk | lungs, trachea, upper esophagus, the part of the larynx below the vocal folds | paratracheal nodes are an important group of nodes in cases of pulmonary infection or lung cancer; also known as: tracheal nodes |
| pulmonary nodes | within the lung parenchyma | lymphatic vessels from the parenchyma of the lung | bronchopulmonary (hilar) nodes | lung parenchyma, bronchial tree within the lungs | pulmonary nodes are located along the larger bronchi of the lung |
| tracheal nodes | coursing along the lateral surface of the trachea and esophagus | superior tracheobronchial nodes | bronchomediastinal trunk | lungs, trachea, upper esophagus, the part of the larynx below the vocal folds | tracheal nodes are an important group of nodes in cases of pulmonary infection or lung cancer; also known as: paratracheal nodes |
| tracheobronchial nodes | along the trachea, around the tracheal bifurcation and primary bronchi | lymphatic vessels from the lung | bronchomediastinal lymph trunk | lungs, visceral pleura, bronchi, thoracic part of trachea, left side of heart, esophagus, posterior mediastinum | tracheobronchial nodes may be divided into five groups: paratracheal (tracheal), superior tracheobronchial, inferior tracheobronchial, bronchopulmonary (hilar), pulmonary |
| tracheobronchial nodes, inferior | inferior to tracheal | bronchopulmonary nodes, left side inferior | right superior tracheobronchial | lower lobes of the lungs; middle | left inferior tracheobronchial nodes |

| | | | | | |
|---|---|---|---|---|---|
| | bifurcation | tracheobronchial nodes drain into right inferior tracheobronchial nodes | nodes | mediastinum; posterior mediastinum | drain to the right side |
| tracheobronchial nodes, superior | superolateral to the tracheal bifurcation | bronchopulmonary (hilar) nodes | paratracheal (tracheal) nodes | lungs, middle mediastinum, posterior mediastinum | inferior tracheobronchial nodes drain lymph from the lower lobe of the left lung to the right superior tracheobronchial nodes |

## Other Tables of Interest:

- Arteries of the Thorax
- Bones of the Thorax
- Fascia of the Thorax
- Joints of the Thorax
- Lymphatics of the Thorax
- Muscles of the Thorax
- Nerves of the Thorax
- Topographical Anatomy of the Thorax
- Veins of the Thorax
- Viscera of the Thorax

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